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### THE DEVELOPMENT AND LONGEVITY OF HAEMAGOGUS MOSQUITOES UNDER LABORATORY CONDITIONS<sup>1</sup>

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The importance of the mosquitoes of the genus *Haemagogus* in the epidemiology of sylvatic yellow fever led us to undertake laboratory experiments with the mechanism of virus transmission with the Villavicencio species. The results of the virus studies have been published in a series of papers by Bates and Roca (1945a, 1945b, 1946a, 1946b, 1946c), which include some notes on the vector mosquitoes. We became particularly interested in the effect of environmental temperature on the establishment and development of the virus in the mosquitoes, and it seemed that temperature conditions favorable for the virus were also favorable for the mosquitoes. The object of the present paper is to summarize these experiments from the entomological point of view.

Mosquito studies were concerned entirely with the Villavicencio population of *Haemagogus* which, in earlier papers, was erroneously called *Haemagogus capricornii*. The population has recently been named *Haemagogus spegazzinii falco* by Kumm, Osorno and Boshell (1946). The three name types (*capricornii*, *spegazzinii* and *falco*) are remarkably similar mosquitoes, distinguished chiefly by slight morphological characters of the male genitalia. The Villavicencio population seems to be morphologically homogeneous, corresponding to the *falco* type. It has been possible to establish laboratory colonies of certain *Haemagogus* species (Osorno, 1944; Hovowitz, 1946), but all attempts with *falco* have been unsuccessful, due to the failure of the adults to mate under cage conditions. Consequently, our studies have been concerned either with adults caught in the forest or with first genera-

<sup>1</sup>The studies and observations on which this paper is based were conducted with the support and under the auspices of the Institute of Special Studies "Carlos Finlay" maintained by the Ministry of Labor, Hygiene and Social Welfare of the Republic of Colombia and the International Health Division of The Rockefeller Foundation.

tion material from such adults. Methods of capture, and the results of field studies, have been published previously (Bates, 1944; 1945); laboratory methods of handling infected mosquitoes have been described in some detail by Bates and Roca (1945a) and are the same as those used in the experiments with adults described in the present paper.

#### SPEED OF LARVAL DEVELOPMENT

Our interest in larval development was primarily practical - to find the most satisfactory method of obtaining adults for experimental purposes. Most of our studies of culture media involved different types of infusion. It is difficult to standardize such infusions so that one experiment can be compared with another, or work at one laboratory repeated in another laboratory. As an example, the results of one set of parallel experiments are summarized in Table I. This shows the

TABLE I

EXPERIMENT WITH GROWTH OF HAEMAGOGUS LARVAE IN VARIOUS CULTURE MEDIA  
(100 first stage larvae in 200 cc. of medium, kept at room temperature,  
mean 25° C.)

Medium	Pupation (Day)					Surviving Larvae on 13th Day	Total Survival through 13th Day
	9	10	11	12	13		
Pure infusion of <i>Inga</i> leaves.....	0	0	0	0	0	36	36
10 per cent <i>Inga</i> infusion + breadcrumbs.....	0	0	0	5	3	43	51
10 per cent <i>Inga</i> infusion + dog biscuit.....	0	0	4	8	10	11	33
10 per cent <i>Inga</i> infusion + brewer's yeast.....	3	10	10	4	6	5	38
Hay infusion (no extra food).....	5	16	14	1	13	44	93
Tap water + bread- crumbs.....	0	0	0	0	0	96	96
Tap water + dog biscuit	0	0	0	0	0	73	73
Tap water + brewer's yeast.....	1	24	13	12	29	17	96

very considerable difference in rate of growth (as well as in survival) in different media. The infusion of *Inga* leaves (*Inga* is a common leguminous tree of the local forests) was long used as a standard medium in the laboratory; yet as can be seen from this table, certain lots of infusion, at any rate, were very unsatisfactory indeed. Results with brewer's yeast were very consistent, and this was later adopted as a standard medium both for raising larvae and for stimulus of egg hatching. The favorable effect of yeast on the growth of mosquito larvae is well known (e. g., experiments of Trager, 1937), and it is used in many types of routine culture media. We used the dried product put up in tablet form by vitamin manufacturers. While this yeast in tap water seemed to be an entirely adequate food for *Haemagogus capri-*

*cornii*, it was not sufficient for *Aedes serratus* or *Psorophora ferox*, though these did well with yeast added to a strong hay infusion.

We made various experiments to determine the effect of temperature on larval growth rate. The results from one set of parallel experiments are summarized in Table II. In this case the larvae were kept individually in shell vials containing tap water to which brewer's yeast was added as food. The amount of yeast was not standardized: rather we attempted to maintain a balance so that some yeast was always present, yet not enough to cloud the water. The yeast, of course, grew more rapidly at high than at low temperatures, so that less was needed at high temperatures. If the yeast grew sufficiently to cloud the water, the larvae were apt to die. The method of feeding each larva separately is subjective, but the results were much more consistent than the results of experiments with known and definite amounts of yeast. In this later type of experiment, a yeast concentration suitable for larvae kept at, say, 20°, would be lethal for larvae kept at 30°. Attempts to grow larvae at a constant temperature of 35° failed, but we do not

TABLE II  
GROWTH OF *HAEMAGOGUS* LARVAE AT VARIOUS TEMPERATURES  
(Parallel experiments with 41 larvae in each lot in individual tubes with  
tap water and brewer's yeast)

Temperature	Average Length of Stages in Days					Total Time Egg to Adult
	I	II	III	IV	Pupal	
20° C . . . . .	5.1	2.9	3.1	8.0	6.9	26.0
25° C . . . . .	3.4	1.8	2.2	5.7	4.9	18.0
Room temperature (mean 25.5° C.)	2.9	1.3	2.0	4.7	4.1	15.0
30° C . . . . .	2.4	1.2	1.6	4.3	3.0	12.5

know whether the failure was the result of a direct effect of the temperature on the larvae, or was caused indirectly by effect on the culture medium.

In the experiments summarized in Table II, the 20° and 30° temperatures were maintained in incubators with fair accuracy, subject only to the hazards of our local power source. The 25° temperature was obtained in a cellar, which during the period of the experiment showed a mean temperature of 24.6°, with an absolute maximum of 25.5° and minimum of 23.0°; the diurnal fluctuation was normally less than 1°. "Room temperature" during the experiment showed a mean of 25.5°, an average maximum of 27.9°, an average minimum of 23.0°, an absolute maximum of 30.5° and an absolute minimum of 21.5°. There seems to be a slight acceleration of development under the variable "room temperature" conditions; otherwise the time-temperature curve for *Haemagogus spegazzinii* is similar to that obtained with other species of mosquitoes (e. g., by Headlee, 1942; Hurlbut, 1943; Huffaker, 1944), though development at any given temperature is



slower with *Haemagogus spegazzinii* than with *Aedes aegypti* or *Anopheles quadrimaculatus*.

The difference in relative length of the four larval stages in mosquitoes is interesting. Possibly the relative length of any given stage is a specific characteristic, since various authors, working with different species, have arrived at different figures (Bates, 1941). In the case of *Haemagogus spegazzinii*, an average of the figures quoted in Table II gives the following proportions for each stage: I, 26 per cent of total larval developmental period; II, 14 per cent; III, 17 per cent; IV, 43 per cent. The distribution under the various temperature conditions is closely similar. The fourth stage seems always to be the longest in mosquito larvae; the possible significance of this has been commented on by Huffaker (1944).

It has often been observed that with mosquitoes, as with other insects, males develop faster than females; but exact figures on the amount of the difference have not come to our attention. The developmental period in the temperature experiments is analyzed by sex in

TABLE III  
LENGTH OF DEVELOPMENTAL PERIOD BY SEX IN *Haemagogus spegazzinii*

Temperature	Developmental Period in:		
	Males	Females	Difference
20° C .	25 6	27 1	1 5
25° C .	17 7	18 2	0 5
Room temperature	14 8	15 4	0 6
30° C...	12 3	12 6	0 3

Table III. To check whether the slowing of female development might be a characteristic of some particular period, such as fourth stage larva or pupa, the data for the 20° group were analyzed in detail. The difference in speed is apparently spread over most of the period of development: the average length of the first stage was the same in both sexes, but the second stage was 0.2 days shorter in males, the third stage also 0.2 days shorter, the fourth stage 0.7 days shorter, and the pupal stage 0.4 days shorter.

#### SIZE OF ADULTS

It has long been known that the lower the temperature of the larval environment, the larger the adults (within a given species, of course). This is based primarily on the observation that spring mosquitoes in the temperate zone are larger than summer specimens of the same species. The subject became of some importance in Europe with the discovery that size was a differentiating character between two anopheline populations in the Netherlands, one a malaria vector and the other not. The history of this has been reviewed by Swellengrebel and de Buck (1938). Nevertheless there seem to be no published data

on the relation between larval environmental temperature and adult size. To obtain such data, we saved the adults from the temperature experiment summarized in Table II. The right wing and right meta-thoracic leg of each mosquito were mounted dry on a slide and measured with an ocular micrometer. Various measurements were taken, but the most satisfactory, as a general index of size, seemed to be the wing length measured from the cleft of the alula to the apex—the alula rather than the base of the wing being taken to avoid error because of differences in the point at which the wing was broken. The data from these measurements are summarized in Table IV.

When we realized how much larger and how much harder the mosquitoes raised at 20° were than those raised at higher temperatures, we adopted 20° as a routine temperature for raising adults for a series of attempts at colonizing the species. Unfortunately, we did not make any clearly comparable tests of adult longevity of mosquitoes raised at

TABLE IV  
RELATION OF LARVAL TEMPERATURE TO ADULT SIZE  
(Length of wing, from cleft of alula to apex in mm.)

Temperature	MALES		FEMALES	
	No Specimens	Length and Standard Deviation	No Specimens	Length and Standard Deviation
20° C	17	2.69 ± .09	16	3.21 ± .06
25° C	14	2.56 ± .07	21	3.01 ± .08
Room temperature	21	2.61 ± .07	13	3.01 ± .05
30° C	18	2.43 ± .08	12	2.84 ± .05

various temperatures, but we had a clear impression that the 20° adults survived adverse conditions much better than those raised at room temperature or at 30°: they were more active in cages, bit more readily (even though unfertilized) and withstood periodic exposures to high temperatures such as would result from leaving the cages for half an hour or more daily in bright sunshine. We did not succeed, however, in inducing sexual activity in such adults.

#### ADULT LONGEVITY UNDER LABORATORY CONDITIONS

Mosquitoes of the genus *Haemagogus* were early suspected as vectors of sylvatic yellow fever, but attempts to obtain virus transmission in the laboratory failed because of difficulty in keeping the mosquitoes alive through the extrinsic incubation period of the virus (Kumm and Frohisher, 1932; Antunes and Whitman, 1937). In these early experiments conventional methods of maintaining mosquitoes were used: the mosquitoes were kept in cages, "protected from the wind and covered with a layer of wet absorbent cotton in order to increase the humidity" (Antunes and Whitman). We used similar methods and obtained similar results: most mosquitoes died in five or six days, and only an

occasional specimen would live through the presumed incubation period of the virus. We found that longevity could be increased if the mosquitoes were kept at low temperatures (20°), but this was of little help since the extrinsic incubation period of the virus would also be greatly prolonged. We made a great many experiments, attacking the problem from various points of view, such as frequency of blood meals, type of food other than blood, type of cage, humidity and temperature, and we eventually worked out quite satisfactory techniques for our purposes. For the most part, these experiments were not controlled with sufficient care to be of value for the analysis of problems of mosquito physiology, and there is no point in summarizing them in detail. They do, however, illustrate the difficulty of laboratory experimentation with problems like longevity, and they demonstrate the specific nature of the physiological adaptations that govern longevity under laboratory conditions, since techniques that were successful with *Haemagogus spegazzinii* were unsuccessful with other diurnal forest mosquitoes and vice versa.

The literature on factors governing insect longevity is enormous, and a very considerable number of studies have been made of the survival of various mosquito species under laboratory conditions. The subject is of obvious practical importance, since the efficiency of a given species as a vector of disease depends, in part, on its relative longevity. Because the study of longevity in nature is very difficult, laboratory study offers a promising line of attack. Outstanding studies of this type, with general reviews of the literature, are those by Russell and Rao (1942) and Sinton and Shute (1938).

The method that we eventually adopted for the maintenance of infected haemagogus has been described in detail in a previous article (Bates and Roca, 1945a). Essentially it consisted in keeping the mosquitoes in individual flat-bottomed glass vials (25x50 cm. in size) with a layer of moist cotton in the bottom covered with a disc of filter paper (to prevent the mosquitoes' getting entangled in the cotton) and plugged with a cup of aluminum (or monel) wire screening containing a small wad of cotton soaked in sugar solution for food. The vials were kept in racks in an environment with air in constant movement: we put fans in all incubators, and when mosquitoes were kept in open rooms, we found it advisable to place them near an electric fan. It seemed, in other words, important that the mosquitoes have a source of moisture always available (the wet cotton in the bottom of the vials) but that they be maintained in a relatively dry atmosphere (usually about 70 per cent relative humidity) with the air in constant movement. Satisfactory survival could also be obtained in a cage with large numbers of mosquitoes if the bottom was covered with moist cotton, and the cage kept near a fan.

We made a total of 290 infection experiments with yellow fever virus in mosquitoes, principally *Haemagogus spegazzinii*. Most of these experiments are of no use for longevity studies, however, since specimens were removed and killed at varying intervals to test for virus development. In some cases the "control" mosquitoes showed that the lot had received no virus, and such lots were often kept specifically for longevity tests. Also, as a general rule, no mosquitoes were

removed from an infected lot during the first 10 days; thus comparison can be made of percentage of survival in the 10-day period under various environmental conditions.

It is interesting that the method of individual vials was satisfactory only with diurnal forest mosquitoes of the canopy zone, such as *Haemagogus* and *Sabethoides* (Bates, 1944); mosquitoes of the forest floor zone, such as *Aedes serratus* and *Psorophora ferox* required quite different treatment. Thus one lot of 26 *Aedes serratus* kept under standard haemagogus conditions in vials at a constant temperature of 30° had a mean life of 4.9 days and a maximum survival of 7 days; the mean life *Haemagogus spegazzinii* under identical conditions was 13.8 days (based on 512 specimens in 14 experiments), with maximum survival about 50 days. In 42 different lots of *spegazzinii* kept under these conditions, survival after 10 days was almost always over 50 per cent, with an average survival for this period of 63 per cent.

On the other hand, *Psorophora ferox* and *Aedes serratus* showed excellent survival in small cages in a subterranean room where the

TABLE V  
SURVIVAL OF MOSQUITOES IN SMALL CAGES IN SUBTERRANEAN ROOM  
(Temperature fairly constant at 25°)

Species	No. Experiments	No. Mosquitoes	SURVIVAL IN DAYS	
			Mean	Average Maximum
<i>Haemagogus spegazzinii</i> . . .	8	205	7.6	13.8
<i>Aedes serratus</i> .	5	138	26.7	51.8
<i>Psorophora ferox</i> .	5	86	20.8	36.8
<i>Psorophora cingulata</i>	4	135	13.4	25.8

temperature was quite constant at 25°, and the humidity nearly saturated. Data from a series of comparable experiments under these conditions with three diurnal forest mosquitoes and one crepuscular species (*Psorophora cingulata*) are summarized in Table V. Under these conditions, one would judge *Aedes serratus* to be a long-lived species and *Haemagogus spegazzinii* a short-lived one precisely the opposite of the results obtained under the conditions described in the preceding paragraph.

The experiments mentioned above were all made with mosquitoes caught as adults and brought to the laboratory. They were thus of unknown age at the start of the experiment. Longevity experiments with such mosquitoes, however, gave quite consistent results; in the case of *Haemagogus spegazzinii*, transmission experiments were made with wild caught mosquitoes throughout the year, with no difference in average survival from one time of year to another. There was, however, a very great difference in survival between wild caught haemagogus and specimens raised in the laboratory at 30°, with yeast as larval food. Four hundred and four such specimens were used in infection exper-

iments; only 28 per cent survived the first 10 days in vials at 30°, in contrast with an average survival of 63 per cent of wild caught specimens (based on 1,423 specimens) over the same period. Comparable experiments were not made with adults bred from larvae kept at lower temperatures, but as remarked above, we have the impression that such adults were much hardier. At any rate, it is clear that in the case of laboratory-bred mosquitoes, the larval culture conditions may have a controlling influence on adult longevity.

It has often been demonstrated that virus infection has no obvious adverse effect on the vector mosquito. To check this a series of 27 consecutive infection experiments in which *haemagogus* were maintained in vials at 30° were selected and divided into three categories: first those in which the source animal was subsequently found not to have circulated virus at the time of the experiment, so that the mosquitoes were uninfected; second, those in which the source animal was circulating only a small amount of virus, so that few mosquitoes were infected; and third, those in which the source animal was circulating a

TABLE VI  
AVERAGE SURVIVAL IN DAYS OF *Haemagogus spegazzinii* IN INDIVIDUAL TUBES  
UNDER VARIOUS TEMPERATURE CONDITIONS

Temperature	No. Experiments	No. Mosquitoes	Average Survival
20° C. constant....	3	66	19.4
25° C. constant ..	3	128	18.3
26.6° C. (20 Hr. 25° C, 4 Hr. 35° C.)	3	154	14.5
30° C. constant...	14	512	13.8
35° C. constant ...	3	132	4.8

large amount of virus, so that about 90 per cent of the mosquitoes were found to be infected. After 10 days, 60 per cent of 331 non-infected mosquitoes, 74 per cent of 283 partially infected mosquitoes, and 60 per cent of 784 heavily infected mosquitoes were still alive.

#### EFFECT OF TEMPERATURE ON HAEMAGOGUS ADULTS

The effect of temperature on the development of virus in *haemagogus* mosquitoes has been discussed in a previous paper (Bates and Roca, 1946b). Transmission experiments were carried out routinely at constant temperature of 30°; but since such temperature conditions would be unknown in nature, we made a few transmission experiments at various other constant and alternating temperatures. We found that virus development in mosquitoes kept for 20 hours at 25° and four hours at 35° daily was almost as rapid as that in mosquitoes kept at 30° constantly. In one set of parallel experiments, for instance, the minimum incubation period for the virus was 28 days at 25°, 23 days at 25°-30°, 12 days at 25°-35°, and 10 days at 30°. We failed to get transmissions at constant temperatures of 20° or 35°. It thus appeared that the four-hour daily exposure to 35° had a very considerable accel-

crating effect on virus development not explainable by the mean temperature, which calculated on an hourly basis would be 26.6°. We thought it would be interesting to attempt to measure the effect of these temperature conditions on the mosquito.

The average survival of *haemagogus* mosquitoes in individual vials under various temperature conditions is summarized in Table VI. The figures are based on few experiments and relatively few specimens; but the results with various individual experiments are quite consistent, and the survival figures are probably significant. It is interesting that survival is shortened by the four-hour daily exposure to 35° below what would be expected from the hourly mean (26.6°).

As a check on the influence of temperature on a physiological process in the mosquito, we kept detailed records on oviposition in several experiments. The results are summarized in Table VII. These mosquitoes all engorged on a monkey at the start of the experiment (the

TABLE VII  
OVIPOSITION OF *HAEMAGOGUS* UNDER VARIOUS TEMPERATURE CONDITIONS  
(88 mosquitoes in each lot)

	TEMPERATURE			
	25° C.	25° C -35° C.	30° C.	35° C.
Per cent alive at 10 days.	53	47	43	2
Average day of first eggs ..	7 2	6 2	6 2	6 5
Per cent laying eggs	61	57	39	5
Total number eggs in 10 days	1144	1121	742	57
Number eggs per mosquito laying	21	22	22	11

infectious meal) and subsequently received no food except sugar solution. It is interesting that the number of mosquitoes laying eggs and the number of eggs laid are practically the same at 25° constant temperature, and at the 25° 35° alternating temperature. Egg development, however, is speeded up by the daily exposure to 35°, being the same (6.2 days) as in mosquitoes kept at a constant temperature of 30°. Egg development in the mosquito seems to act like virus development. The number of mosquitoes laying eggs is appreciably reduced at the constant temperature of 30°, more so than would be explicable by the increased mortality. The number of eggs per mosquito laying, however, remains the same: in other words, a certain proportion of individuals are inhibited from oviposition by the constant temperature of 30°. A constant temperature of 35° seems to be very unfavorable for *Haemagogus spegazzinii* from every point of view.

#### DISCUSSION

*Haemagogus spegazzinii* is a diurnal forest mosquito with a peak of activity toward mid-day; it is found most abundantly in the forest canopy or in open sunny clearings or around forest margins. Its bright

metallic coloration may be an adaptation to this relatively dry and warm environment. The larvae have been found in tree-holes, most commonly in holes with very narrow apertures; they are scarce in relation to the number of adult mosquitoes, and it seems likely that the chief breeding place is some type of tree-hole or container habitat that has been overlooked in forest studies. Conditions favorable for haemagogus survival in the laboratory are very different from conditions favorable for the survival of the mosquitoes of the forest floor zone (*Psorophora ferox* and *Aedes serratus*), and it is difficult to avoid the conclusion that these laboratory differences reflect physiological adaptations to the different natural environments. A constant high relative humidity seems to be definitely unfavorable for haemagogus and these mosquitoes are very short lived when kept in a subterranean room in small cages with added moisture—conditions that seem to be ideal for the mosquitoes of the forest floor zone (Table V). The mean life in cages in such a room was 7.6 days; whereas at the same temperature (25°) in individual vials with screen stoppers, in an incubator provided with an electric fan, the mean life was 18.3 days (Table VI). It is well known that many mosquitoes avoid extremely high humidities (Thomson, 1938), but in general the higher the humidity, the longer the survival (Hundertmark, 1938; Lecson, 1939). It would be interesting to investigate the mechanism of the unfavorable effect of the cellar environment on haemagogus.

The correspondence between conditions favorable for haemagogus mosquitoes and conditions favorable for yellow fever virus is interesting. A constant temperature of 30° was very favorable for virus development, but relatively unfavorable for the mosquitoes; twenty hours daily at 25° and four hours at 35°, however, proved to be almost equally favorable for the virus, and much better for the mosquitoes than the constant temperature. It is very likely that the mosquito would be subject to an alternating temperature of this order of magnitude in nature, since 25° is close to the mean forest temperature at the floor zone, where conditions are quite constant day and night, and 35° is a very likely body temperature for daily periods of activity in a sun-loving mosquito like haemagogus.

It is interesting to speculate as to the possible nature of the "optimum" temperature for these various processes. With regard to larval development, the "optimum" is generally considered to be the temperature at which the greatest speed of development coincides with a minimum mortality (e. g., Mosna, 1937) or perhaps the highest temperature at which clearly adverse effects are not apparent. Yet "optimum" carries the connotation of "most favorable for the species," which surely involves many factors other than mere speed of growth. In haemagogus, for instance, the size (and apparently the hardness) of the adult is in part a function of the larval temperature, and this would have to be taken into account in attempting to determine what larval temperature would be most favorable for the species. In the case of adults, survival under protected conditions is longer the lower the temperature, but in nature this longer survival might be counterbalanced by the slowing up of physiological processes such as egg development, and the consequent greater hazard of accident to the

mosquito before these processes were carried through. In this case, the highest temperature at which adverse effects are not demonstrable might well be the "optimum" for the species. That such adverse effects appear is shown by the decreased oviposition, for instance, at 30° and 35° in the present studies. The fact that egg development proceeds at the same rate at the 25°-35° alternation of temperature as at the constant temperature of 30°, and that oviposition and survival are much greater at the alternating temperature, might well be taken as indicating that some such conditions as these were "most favorable for the species." They are certainly most favorable for the virus!

#### SUMMARY

Experiments were carried out testing the effect of food and larval temperature on the development of *Haemagogus spegazzinii*. Brewer's yeast was found to be an excellent food for this species, though inadequate for *Aedes serratus* or *Psorophora ferox*. Larval development required 26 days at 20°, 18 days at 25° and 12.5 days at 30° C. Adults developing from larvae kept at lower temperatures were larger (and apparently hardier) than those from larvae kept at higher temperatures. Data are given on the difference in size. Of the total period of larval development, 26 per cent was spent in the first stage, 14 per cent in the second, 17 per cent in the third, and 43 per cent in the fourth, the proportions being the same at the various temperatures tested. The males developed faster than the females, the increase in developmental speed being demonstrable from the second larval stage on.

Survival of *Haemagogus spegazzinii* was very unsatisfactory with mosquitoes kept in cages provided with moisture and maintained in a room at 25° with a high relative humidity. Survival of mosquitoes of the forest floor zone (*Aedes serratus*, *Psorophora ferox*, *P. cingulata*) was excellent under these conditions. *Haemagogus* seemed to require an adequate supply of available moisture, but a relatively dry atmosphere; and best results were obtained with mosquitoes in individual screen-stoppered vials with constant air movement provided by an electric fan. Survival of *Aedes serratus* and similar mosquitoes was very poor under these conditions.

Survival of *haemagogus* adults bred from larvae kept at 30° was very poor, as compared with survival of wild caught adults. Infection with yellow fever virus had no effect on adult longevity.

In general, the lower the temperature, the longer the survival of adults within the range tested (20°-35°). Unfavorable effects measurable in decreased oviposition were apparent at 30° and 35°. Speed of egg development (and virus development) was almost the same at an alternating temperature of 20 hours daily at 25° and 4 hours at 35° as at a constant temperature of 30°; the proportion of specimens ovipositing and the average length of life were both greater at the alternating temperature. The difference between behavior at 25° and at the 25°-35° alternation cannot be accounted for by the increase in mean temperature, since this, calculated on an hourly basis, was only 26.6°.

The relation between the laboratory results and the habits of the mosquito in nature is discussed, together with some comment on the significance of the concept of "optimum temperature."



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## BUTTERFLY AGGREGATIONS IN TEMPERATE REGIONS

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The idea prevails that butterflies generally lead solitary lives. In the tropics, however, at certain seasons, aggregations of them often appear on the landscape. They are usually quite conspicuous and colorful, and not only are they of frequent occurrence, but also they often comprise immense numbers of individuals.<sup>1</sup>

Aggregations of butterflies also occur in temperate lands, but are overlooked for the most part by behavior students because of their less frequent occurrence, the small size of the congregations and their lack of brilliant colors. But regardless of the region in which the butterflies live, the impulse for sociability is quite the same and has, so far as I can see, nothing at all to do with food or courtship.

As an example of butterfly aggregations in temperate regions, I am glad to record an observation in St. Louis County where, on the sunny afternoon of September 13, 1942, I found along a half-mile stretch of a partially dry creek-bed, about twenty-five aggregations of four species of butterflies.<sup>2</sup> The participants in the little drama were:

The black and red, *Phycoides tharos* Drury (Fam. Nymphalidae).

The small Sulphur, *Eurema lisa* Bdv. & LoC. (Fam. Pieridae).

The large Sulphur, *Catopsila cubule* Linn. (Fam. Papilionidae).

The small blue *Everes comyntas* Godt. (Fam. Lycaenidae).

The number of individuals in these aggregations varied greatly; no two groups were alike. However, they fell roughly into four categories, a sample of each of which is herewith presented.

### AGGREGATION A

This is a sample of seven groups made up of rather definite units, this particular major group having eight parts, as follows:

Unit No. 1. 150 *E. comyntas* Blue.

Unit No. 2. 12 *E. lisa*, 1 foot East of Unit 1—Small Sulphur.

Unit No. 3. 1 *E. lisa*, 3 feet North of Unit 1—Small Sulphur.

Unit No. 4. 50 *E. comyntas*, 2 feet West of Unit 1—Blue.

Unit No. 5. 12 *E. lisa*, 12 feet West of Unit 4—Small Sulphur.

Unit No. 6. 3 *P. tharos*, 2 feet South of Unit 5—Black and Red.

Unit No. 7. 7 *E. lisa*, 3 feet North of Unit 5—Small Sulphur.

Unit No. 8. 2 *P. tharos*, 2 feet West of Unit 6—Black and Red.

In this sample aggregation we have representatives of three species, comprising 237 individuals, resting in eight small, irregular groups near

<sup>1</sup>See "Clouds of Butterflies in Mexico. A Study on Butterfly Aggregations." Entom. News 53: 121-126, 151-154, 181-184, 1942.

<sup>2</sup>The butterflies were kindly identified by Mr. Carl Heinrich.

to one another. Friendliness seemed to be the order of the day, yet there was absolutely no intermingling of the species; each species kept strictly to itself.

#### AGGREGATION B

Here is a sample of another kind of group which appeared six times on the half-mile of creek-bed. The group consisted mainly of about 85 small Sulphurs, *E. lisa*, but scattered among them were a dozen large Sulphurs, *C. eubule*. The small butterflies have black markings on the wings, but when at rest with the wings erect the marks are concealed. Both species together, therefore, form a solid mass of yellow. In every case among the six "combination aggregations" on the creek-bed, the large Sulphurs were greatly in the minority. The largest group of this kind had 115 *E. lisa* and 15 *C. eubule*. There were also several groups composed entirely of the small *E. lisa*, but no instance was found of *C. eubule* forming a group alone; they were always in company with the small Sulphurs.

#### AGGREGATION C

The blue *E. comyntas* was by far the most abundant in the area. In addition to congregations of these in close proximity to the other species, there were often groups of from 10 to 50 in places isolated from all other groups of their own or other species.

#### AGGREGATION D

The black and red *P. tharos* were in the minority. In addition to a few small gatherings of them near other groups, there were sometimes isolated groups of only 2 to 5 individuals.

#### DISCUSSION

The observations show that while all four species were gregarious, two of them, *P. tharos* and *E. comyntas*, kept strictly to themselves in groups of their own species. The same was also true in only part of the cases for the small Sulphur, *E. lisa*, but the latter often permitted the large Sulphur, *C. eubule*, to enter its groups. The large Sulphurs, in this locality at least, were never found in a group of their own species exclusively, but joined the groups of the small Sulphurs. Here it appears that color perception may be a factor to bring the two yellows together, and this in spite of the fact that the two kinds of butterflies belong to distinct taxonomic groups. These few observations, however, give us no evidence as to whether color perception or olfactory recognition brings each species into groups of its own kind.

An equally important aspect of this habit of assembling is its relation to societal evolution. The gregariousness that we note in butterflies may be low in the scale of psychic development, but nevertheless their predilection for sociability may yet prove to be one of the early steps in the scheme of the evolution of social life among insects.

# EMBRYOLOGY OF LUCILIA SERICATA MEIGEN

(Diptera: Calliphoridae)

## PART I. CELL CLEAVAGE AND EARLY EMBRYONIC DEVELOPMENT

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Investigations in insect embryology can be traced back to the early 19th century which period included the works of Herold (1815) on Lepidoptera and Humel (1835) on the roach. In 1843 K  lliker published a comparative study of insect and vertebrate development. The first comprehensive work on dipterous embryology was that of Weismann (1863). Kowalewsky (1871) whose research dealt with worms and arthropods was the first investigator to study fixed and sectioned material. Graber's (1879, 1888, 1889, 1890) works on muscid development represent probably the most extensive treatise on dipterous embryology. Gambrell (1933) lists the Diptera whose development has been studied up to 1932. A complete list of references dealing with dipterous embryology is contained in Johansen and Butt (1941). The embryology of several species of *Lucilia* has been investigated by Graber (1881, 1889), Escherich (1900, 1902) and Noack (1901) but apparently no study has been made on the development of *Lucilia sericata* Meigen.

The purpose of this research is the determination of the exact nature of cell cleavage and the migration of the cleavage cells to the egg periphery in *Lucilia sericata*.<sup>2</sup>

### MATERIALS AND METHODS

*Lucilia sericata*, the sheep blow-fly, was selected as the subject of this embryological investigation because of the abundance of available material, the ease of egg collection and the size of the egg. The chief difficulty encountered was the rapidity of development as some of the eggs complete their development in as quickly as 15 hours (24 hours is about the average). This difficulty was remedied by two measures: first, by collecting eggs every five minutes and second by taking large samples of eggs thereby assuring a complete series of developmental stages. Approximately 250 eggs were fixed and sectioned for this study.

The eggs necessary for this investigation were obtained from stock cultures of flies reared in the insect rearing room in the sub-basement of the Botany and Zoology Building, Ohio State University. Two-day-old

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pupae were selected which were placed in a glass rearing cage. After emergence the adults were given a diet of lean hamburger, rock candy crystals and water. Oviposition began about the fifth day. Of the females observed the eggs were laid in clusters on the sides and under-surfaces of the meat. Each cluster consisted of from 6 to 7 eggs to, in many cases 75-100. Immediately after oviposition of several clusters (from 1 to 3 minutes) the egg masses were removed to a temperature of 21° to 22° C. They were fixed immediately upon deposition and at intervals of five minutes thereafter up to four hours. The eggs were fixed in hot Bouin's fixative. This fixing fluid was heated in small glass vials in a water bath of 70° C. Immediately after the placement of eggs in the fluid the vials were removed from the bath and allowed to cool at room temperature. After remaining in the fixative for 4 hours they were washed in 70% alcohol until the yellow color of picric acid disappeared and then stored in 70% alcohol.

To facilitate handling during infiltration and imbedding it was necessary in most cases to stain first in toto. The following stains were used: Grenacher's Borax Carmine, Delafield's Haematoxylin in various proportions with water, Eosin, Aniline Blue and Acid Fuchsin. Delafield's Haematoxylin, 1 part to 3 parts water, was the most rapid and consistent. It was necessary to remove both the chorion and vitelline membrane for quick and uniform staining in all eggs more than 15 minutes old.

After several weeks storage in alcohol the vitelline mass will shrink appreciably away from both the chorion and vitelline membrane. This shrinkage was most noticeable at the poles. The chorion in most cases could be incised at either pole with a minute needle and the egg with its vitelline membrane popped out of the incision. If appreciable shrinkage has occurred at the poles the vitelline membrane could be removed in a fashion similar to that of the chorion. In cases where it still contacted the vitellus at the poles it could be peeled off by holding the egg firmly in place with one minute needle and peeling with the other. Frequently tearing of the egg would occur in the area of initial peeling so it became necessary to vary the location of this area in each age group studied. In a few cases mild shaking of the vial would remove both the chorion and vitelline membrane.

The schedule for dehydration prior to clearing and infiltration depended on the stain used. Aqueous stains (in toto) were followed by: 35% alcohol 5 minutes; 70% alcohol 5 minutes; 95% alcohol 10 minutes; 100% alcohol 30 minutes; 2 parts 100% alcohol, 1 part cedar oil 60 minutes; 1 part 100% alcohol, 2 parts cedar oil 60 minutes; pure cedar oil until clear, usually one hour to overnight. To insure complete dehydration and for convenience the majority of eggs were cleared overnight. Clearing for several days in cedar oil did not seem to be harmful to the egg structures. Before the transfer from the clearing agent to paraffin the eggs were briefly rinsed in xylene to remove the film of cedar oil on the egg surface.

The period of infiltration varied from 1 to 5 hours with no apparent differences noted either during sectioning or in sectioned material. The summer paraffin mixture (56°-58° C.) was used successfully in most cases. Four methods of imbedding were employed; the paper

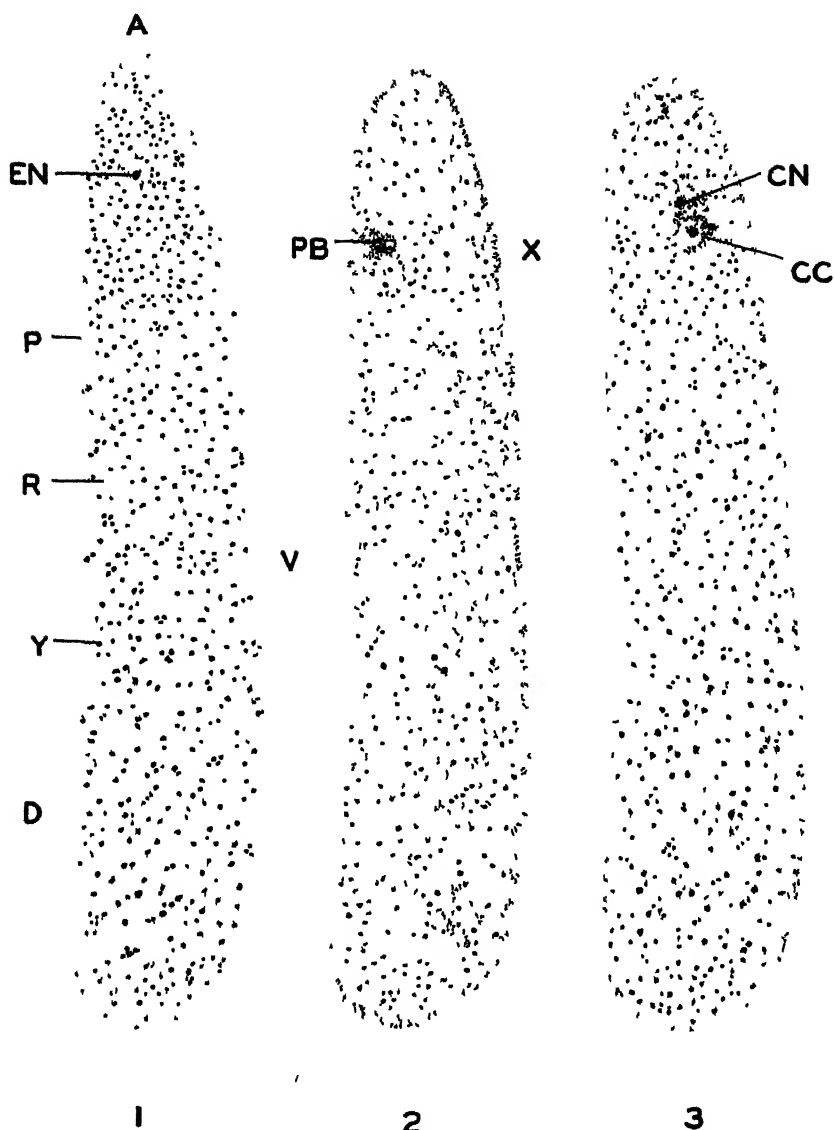


FIG. 1. Age 1-5 minutes. Egg nucleus centrally located prior to reduction division. A—anterior; D—dorsal; EN—egg nucleus; P—periplasm; R—reticulum; V—ventral; Y—yolk.

FIG. 2. Age 5-15 minutes. Egg nucleus moves to periphery. Reduction division occurs here. Clear areas indicate vitelline spheres. PB—polar body.

FIG. 3. Age 5-15 minutes. Two-cell stage; nuclei centrally located. CC—cleavage cell; CN—cleavage nucleus.

box, Syracuse watch glass, the bottom portion of a small glass vial, and small (about  $\frac{1}{2}$  inch diameter) cups made from celluloid. The latter proved by far the most advantageous because of its ideal size and flexibility. Both the temperature controlled oven and the table lamp methods of heat source for infiltration were used with the latter more satisfactory and convenient. Accurate orientation was not attempted during imbedding in order to prevent crystallization of the paraffin in the region of the future embryo; this sometimes happens when hot needles were used for orientation in imbedding. The eggs were removed from the infiltration mass by means of torn edges of filter paper and quickly dropped into the melted imbedding mass in the celluloid cup. The eggs sank to the bottom of the paraffin mixture which had been previously chilled for about three seconds in ice water. Immediately after the egg came to rest horizontally the liquid paraffin surface was breath-blown solid and the cup was immersed in chilled water. Using two of these cups ten embryos could be imbedded in as many minutes.

The paraffin blocks each containing one embryo were trimmed until their thickness did not exceed over three times the diameter of the embryo. Thus the outline of the stained embryo was clearly visible. Final orientation was accomplished during sectioning by adjusting the "swivel joint" containing the block holder. The width of the sections varied from 2 to 9 microns depending on whether structure or location of cleavage cells was desired; 5 microns were satisfactory for most stages. The sagittal sections were best prepared by cutting with the blade parallel to the longitudinal axis of the egg. The ribbons were mounted on glass slides treated with egg albumen by flotation on cold water and spreading was accomplished by placing a heated slide directly underneath or by direct flame from an alcohol burner. All air bubbles were removed from the spread sections with warm fine needles. The slides were dried overnight at room temperature.

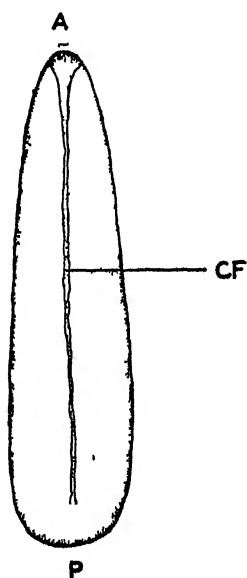
Various stains were employed to determine the early nuclear arrangements and cell migration prior to the formation of the blastoderm. The following were tested: Delafield's Haematoxylin in various proportions with water, Delafield's Haematoxylin followed by Eosin, acid Delafield's Haematoxylin, Heidenheim's Iron Haematoxylin singly or followed by picric acid or Masson's triple stain (Aniline Blue, Phosphomolybdic Acid and Acid Fuchsin) and Mayer's Carmalum. When Heidenheim's Iron Haematoxylin was used singly the schedule given by Kennedy (1932) was followed; when followed by Picric Acid that of Auten (1934). The better preparations were obtained with the haematoxylins used separately. The sections were cleared in xylene, mounted in dilute balsam and dried overnight at 40° C.

Plates I, II, III and IV are composite drawings of longitudinal sections.

#### THE EGG

The egg of *Lucilia sericata* is elongate (about 1380 microns), pearly white with a slightly flattened dorsal surface and a decidedly convex ventral surface. The anterior pole (about 190 microns) in most cases

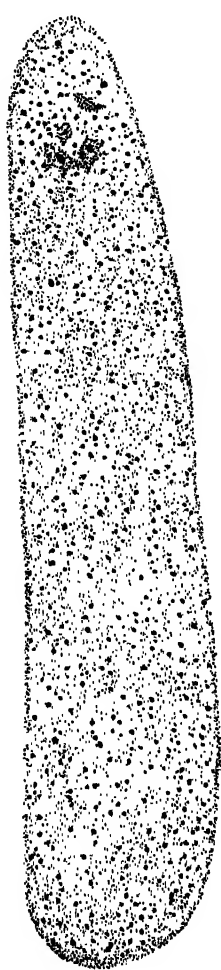
is strongly curved and almost pointed while the posterior pole (about 280 microns) is but gently curved and broadly rounded. The egg is covered on the outside by a complicated chorion which in surface view consists of a network of polygonal impressions and in cross section of a thin outer smooth layer and an anastomosing inner layer. (Pl. VI, fig. 23). Except in the region immediately underlying its two dorsal folds the chorion lies in close contact with the vitelline membrane, a thin non-cellular membrane lying below the chorion. Immediately after deposition the chorion is very soft and pliable and easily permeated by haemotoxylin stains. At this stage there is little if any indication of the vitelline membrane which hardens into a definite structure after about 15 minutes.



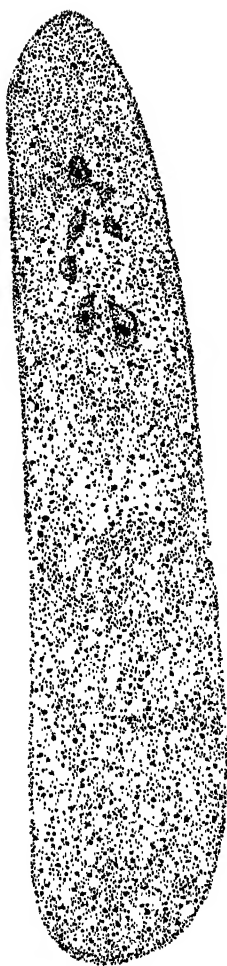
Text Figure 1

The egg proper consists of the (1) periplasm, a definite thin outer layer of formative protoplasm slightly thicker at the poles, (2) a reticular layer of protoplasm in which the deutoplasm or yolk is contained, and (3) a single egg nucleus surrounded by nuclear protoplasm, located in the anterior third of the egg. (Pl. I, fig. 1). In the dorsal region of the posterior pole the periplasm contains the oosome, (Pl. III, fig. 9; Pl. VI, figs. 20, 21), a special inclusion which bears a direct relationship to the primordial germ cells. In fixed and stained preparations the deutoplasm consists of deeply staining yolk bodies in the form of spheres of various diameters and of spheroid cavities which are indicative of the regions occupied by the vitelline spheres. These vacuolated spaces probably represent yolk material soluble in either the fixing fluid or in one of the chemicals used in tissue preparations.

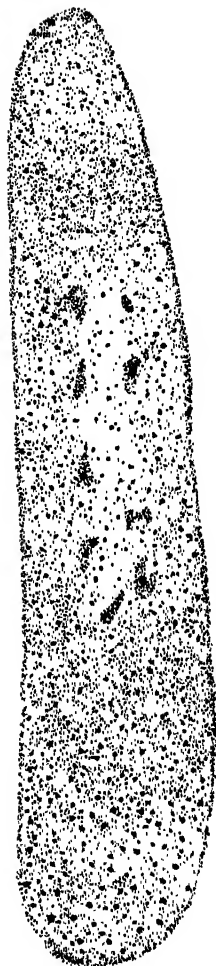




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FIG. 4. Age 15-30 minutes. Four-cell stage; three nuclei shown.  
FIG. 5. Age 30-45 minutes. Eight-cell stage; four nuclei shown.  
FIG. 6. Age 30-60 minutes. Sixteen-cell stage; cell configuration medial.

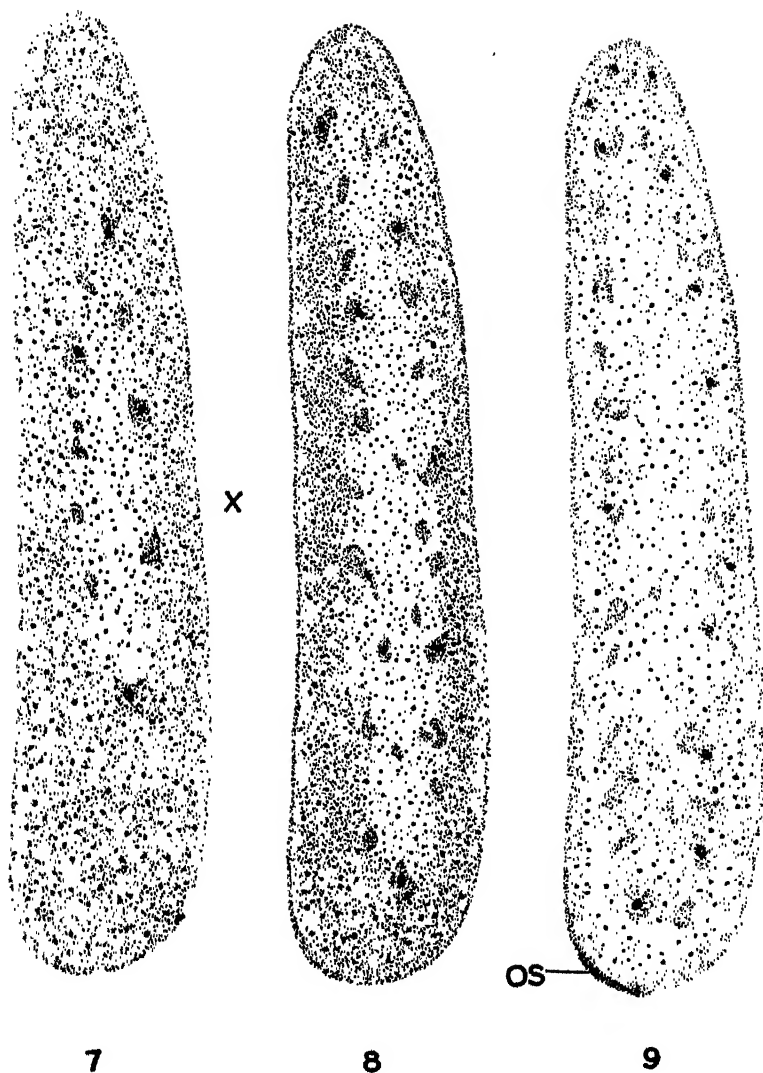


FIG. 7. Age 45-60 minutes. Thirty-two cell stage showing cell migration anteriorly. Reticulum within cell configuration greatly diminished.

FIG. 8. Age 60-75 minutes. Cells arranged at regular distances from egg center; nuclei displaced slightly peripherally in cells.

FIG. 9. Age 90-120 minutes. Cleavage cells more crowded in anterior pole; nuclei displaced peripherally. OS—Oosome.

## MATURATION AND FERTILIZATION

Fertilization occurs in most insects after the egg membranes have formed. The sperm (polyspermy is the rule) from the spermatheca, enter the egg through one or more micropyles as the egg passes down the oviduct prior to oviposition. My attempts to determine the presence of sperm in any of the eggs studied proved fruitless. In over 50 prepared eggs from 1 to 15 minutes old, no trace of sperm was observed. In all probability the gametes fuse after about 5 to 10 minutes after deposition of the egg since in normal development, reduction division of the egg nucleus must occur before its subsequent union with the male gamete.

Immediately after deposition of the egg, the egg nucleus may be found first centrally, then dorso-laterally and finally fused with the periplasm in the anterior third of the egg. This area of fusion (Pl. I, fig. 2), slightly lateral to the dorsal surface contains the polar body. Indications are that only one polar body is formed from the maturation division. Although it is impossible to state with certainty, the lateral migration of the egg nucleus to the periplasm seems to be in a slightly posterior direction. After reduction division the female gamete migrates back towards the center of the egg, where fertilization probably occurs and begins to divide.

## EARLY CLEAVAGE

Purely for purposes of convenience cleavage was arbitrarily divided into two separate stages. The first stage, early cleavage, deals with synchronous divisions, a condition where the daughter cleavage cells divide simultaneously or almost so. The second stage, late cleavage, deals with heterochronous divisions, a condition where the divisions of the daughter nuclei occur at different times.

Johannsen and Butt (1941) recognize the following types of cleavage in insects: (A) purely total—this type occurs among the Proctotrupidae, Chalcidae and some others and is especially concerned with cases of polyembryony; (B) combination cleavage—this type involves total cleavage at first which later becomes superficial. Combination cleavage occurs in the group Collembola; (C) superficial—the majority of insects undergo this type of cleavage where the nucleus divides into daughter nuclei which by repeated divisions and migration invest the periplasm and establish the so-called blastoderm or primary epithelium. The eggs of *Lucilia sericata* fall into this category.

Following fertilization the fusion or cleavage nucleus is located in the anterior third of the egg. Here it divides into two daughter nuclei (Pl. I, fig. 3) which migrate both laterally and posteriorly. Each of these two cleavage nuclei is surrounded by cytoplasmic masses of almost equal size and are joined to each other by the egg reticulum which anastomoses throughout the entire egg. Thus the most distant portions of the egg have a distinct morphological association with the cleavage nuclei even though the latter have their specific loci in the anterior region. The second division produces four cells (Pl. II, fig. 4) which migrate posteriorly and in turn divide simultaneously into eight cells (Pl. II, fig. 5). Lines enclosing the outer edges of these cells

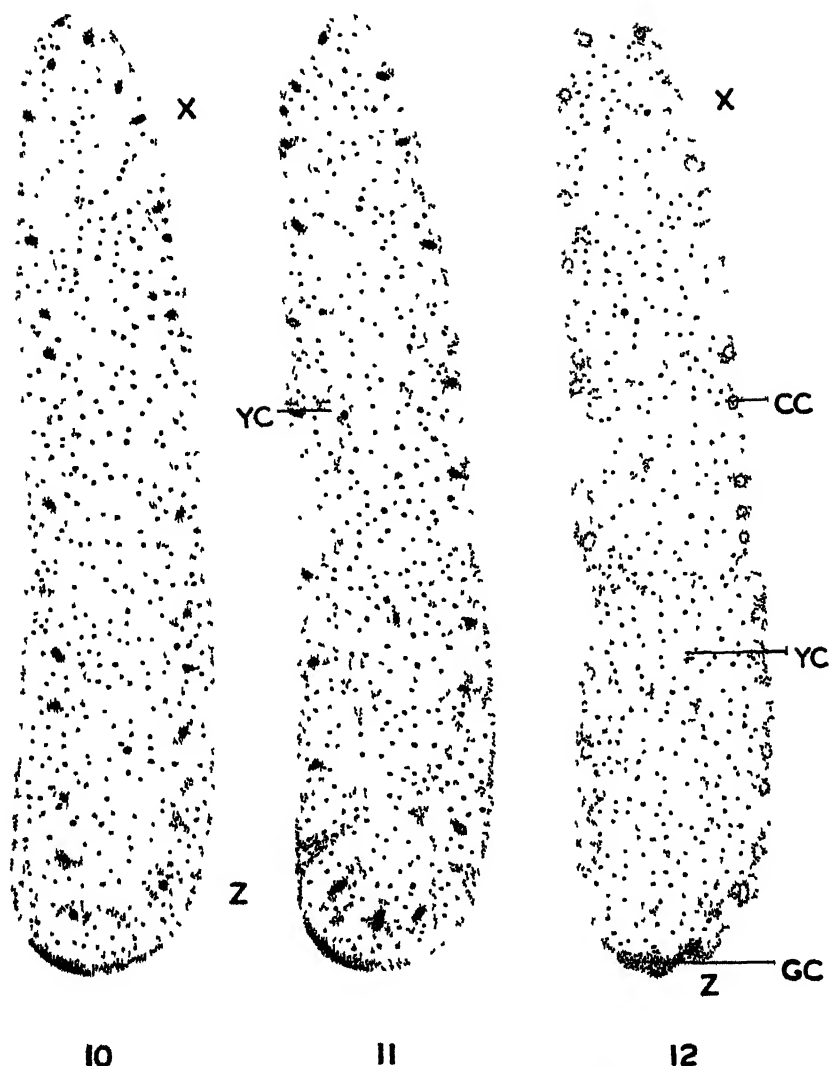


FIG. 10. Age 90-120 minutes. Cleavage nuclei penetrating periplasm in anterior third of egg. Primary yolk cells first appear in this region.

FIG. 11. Age 105-120 minutes. Periplasmic investment complete except for posterior polar region. Primary yolk cells now definite with their nuclei displaced medially. YC—yolk cell.

FIG. 12. Age 105-120 minutes. Cleavage cells complete their periplasmic fusion; nuclei appear vacuolate; oosome broken up and absorbed by cleavage cells, in posterior pole forming the germ cells. GC—germ cell.

would form a figure closely resembling the shape of the anterior half of the egg in which they are located. Sixteen cells (Pl. II, fig. 6) are formed from the next division which become arranged at almost regular distances from the center of the egg.

Probably the cessation of synchronous division occurs in the next division. In two preparations, I have observed a 20 and a 22 cell stage (Pl. V, fig. 15) with all the cells well separated from each other. Although these intermediate cell numbers may have been due to abnormal development I am of the opinion that the beginning of random division occurs during this stage of development. This opinion is augmented by the fact that synchronous divisions apparently do not occur after the 32 cell stage. (Pl. III, fig. 7). Probably the most significant phenomenon in this division is the migration of cells in three directions, anteriorly, posteriorly and laterally. Up to this point, migrations have been confined to the last two mentioned directions.

Concerning the ultimate causes for these simultaneous divisions and subsequent peripheral migration very little is known. Johannsen and Butt (1941) list two theories, that of Miller (1939) and that of Sehl (1931). Miller regards migration as passive drifting due to local changes in and near the cells with synchrony of division due to simultaneous nuclear influences. Sehl suggests that migration is due to the attraction of the periplasm upon the nuclei.

The central location of the cleavage cell nuclei during the first five divisions is fairly constant although their shape may vary considerably. The circular type is most common but variations ranging from the elongate to the tear-shapes are frequent. These tear or pear shaped nuclei may have their apices directed either centrally or peripherally.

The contour of the cleavage cells is very irregular and amoeboid. The irregular surface is due to indentation of the yolk globules surrounded on their margins by protoplasmic processes of the cleavage cells which merge with the reticulum. As no cell walls are present a true syncytium exists. Usually the more blunt portions of the cells face centrally. The reticulum enclosed by the cleavage cells appears only as narrow strands as compared to the rather heavy protoplasmic network lying between the cells and the cortical layer. This diminution of cytoplasm from the reticulum is in all probability associated with the formation of the nuclear cytoplasm of the cleavage which probably explains this reticular loss.

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#### EXPLANATION OF PLATE V

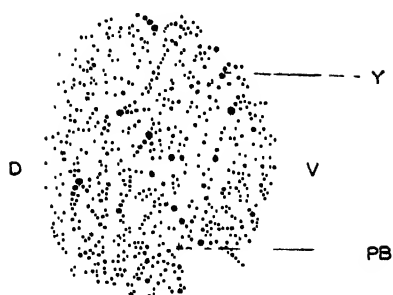
FIG. 13. Age 1-5 minutes. Transverse section approximately 130 microns from anterior pole showing polar body location. D—dorsal; PB—polar body; V—ventral; Y—yolk.

FIG. 14. Age 5-15 minutes. Transverse section at level of X, Pl. I, Fig. 2, showing the central location of a fusion nucleus. CN—cleavage nucleus; P—periplasm.

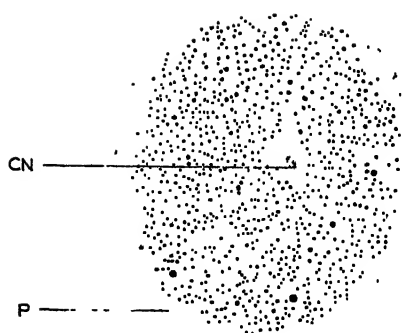
FIG. 15. Age 30-45 minutes. Transverse section through middle of a twenty-two cell embryo. CC—cleavage cell.

FIG. 16. Age 30-45 minutes. Transverse section at level of X, Pl. III, Fig. 7, of a thirty-two cell stage.

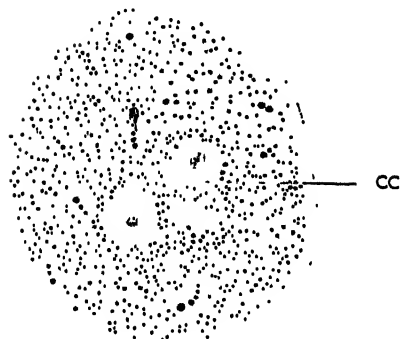
FIG. 17. Age 90-105 minutes. Transverse section at level of Z, Pl. IV, Fig. 10, showing horse-shoe shaped cleavage cells with their nuclei displaced peripherally.



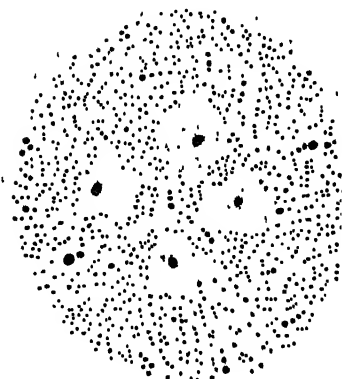
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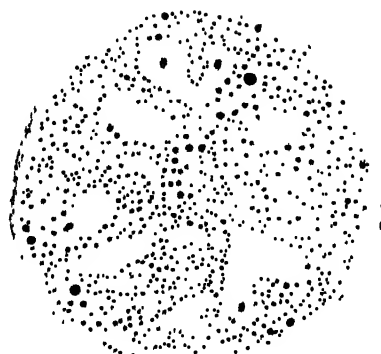
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15



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17

## LATE CLEAVAGE

Late cleavage involves (1) heterochronous cell division, (2) investment of the cleavage nuclei in the periplasm, (3) the formation of primary yolk cells, and (4) the beginnings of the primordial germ cells. Following the establishment of the 32-cell stage the cleavage cells undergo several divisions prior to their peripheral investment. Judging from the total number of cells from consecutive age groups the number of consecutive divisions is three. Each division and migration of cells increases the dimensions of the "hollow figure" of cells which is slightly displaced and concentrated towards the anterior pole. Thus the cells are brought closer and closer to the periplasm until fusion finally occurs. (Pl. IV, fig. 10; Pl. VI, fig. 18).

Both the time and place of cleavage cell penetration into the periplasm vary in different groups of insects. In some they reach the surface simultaneously and in others at some particular position in the egg such as the anterior or posterior pole on the ventral surface. In *Lucilia sericata* the region of initial investment is located near the anterior pole in about the same horizontal plane as the original cleavage nucleus. This fusion apparently occurs dorsally, ventrally and laterally at the same time. From this initial area fusion occurs both anteriorly and posteriorly until the cleavage cells finally reach the posterior pole. The outer surface of the egg in section now appears irregular because of the outward "pressure" of migrating cleavage cells on the periplasm. (Pl. IV, fig. 12; Pl. VI, fig. 19).

The cell nucleus, immediately prior to the fusion of the cleavage cells with the periplasm, no longer occupies a central position but is now located towards its outer margin. After about the second division following the 32-cell stage the cleavage cells become horse-shoe shaped with a nucleus in each arm of the shoe. (Pl. IV, figs. 10, 11; Pl. V, fig. 17). These binucleate cells then divide producing two elongate triangular cells (Pl. VI, fig. 18), which penetrate the periplasm, blunt edge leading.

Yolk cells are classified as to their time and place of origin. The primary yolk cells are those which do not reach the periphery but remain behind in the yolk. The secondary yolk cells are those which migrate back into the yolk during the formation of the blastoderm. We are concerned here with the origin of the former. Both in sagittal (Pl. IV, figs. 11, 12) and transverse sections (Pl. VI, fig. 19) large amoeboid cells can be seen near the cleavage cells that have penetrated the periplasm. These cells, the primary yolk cells, are identical to cleavage cells with the exception that their nuclei are medial and that unlike true cleavage cells they do not enter the periplasm but return into the yolk. In *Lucilia sericata* they are rather numerous.

Since this paper is concerned chiefly with cleavage, only the briefest mention will be made of the origin of germ cells. They would have been excluded entirely except for the fact that they arise from formative protoplasmic investment. As already mentioned the dorsal surface of the periplasm of the posterior pole contains the oosome. Several cleavage cells penetrate this region, break up and absorb this inclusion and form very dark circular masses (Pl. IV, fig. 12; Pl. VI, fig. 22),

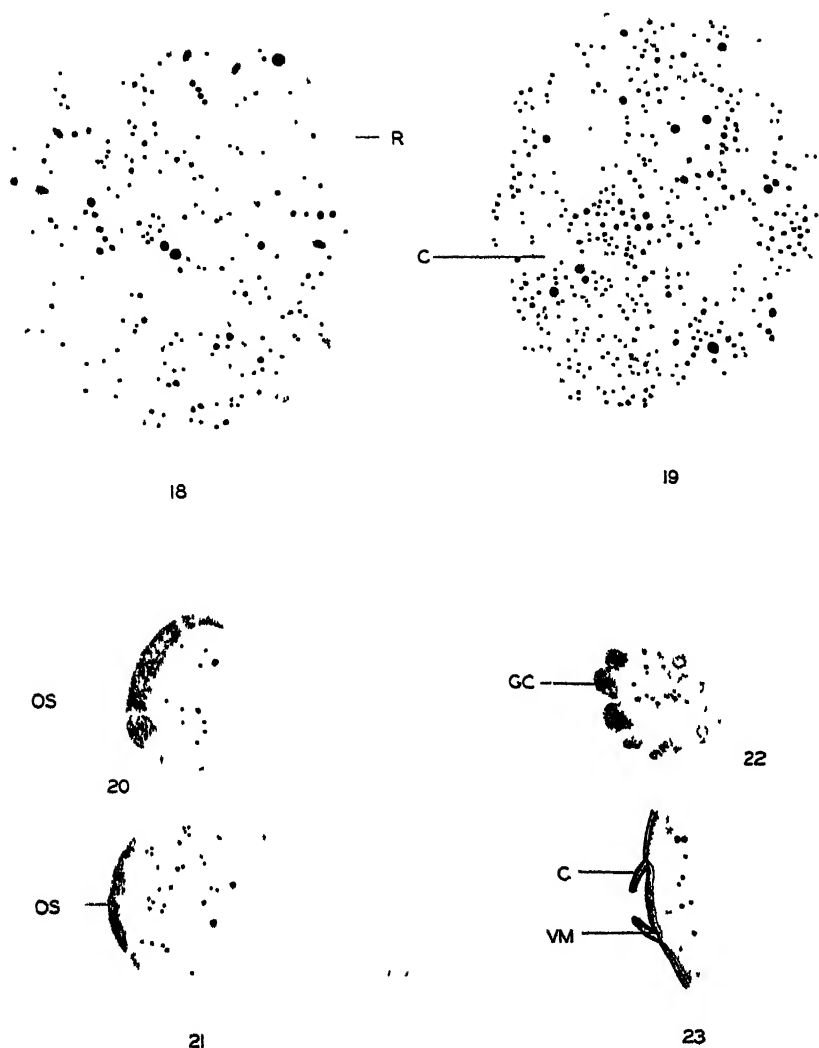


FIG. 18. Same egg as in Fig. 17 at level of X, showing fusion of the cleavage nuclei with periplasm. R—reticulum.

FIG. 19. Age 105-120 minutes. Transverse section at level of X, Pl. IV, Fig. 12, showing cleavage nuclei in periplasm; five yolk cells are shown.

FIG. 20. Age 30-45 minutes. Transverse section about 10 microns from posterior pole showing oosome on dorsal surface. OS—oosome.

FIG. 21. Same egg as in Fig. 20, 15 microns from posterior pole. OS—oosome.

FIG. 22. Age 105-120 minutes. Transverse section at level Z, Pl. IV, Fig. 12 showing 4 germ cells protruding from dorsal surface. GC—germ cell.

FIG. 23. Age 1-5 minutes. Transverse section of dorsal surface through chorionic folds (see text fig.) showing membrane-egg relationship. C—chorion; VM—vitelline membrane.



which slightly protrude from the polar surface. These cell masses are the anlage of the primordial germ cells.

#### SUMMARY

1. The time required for egg development up to the formation of the germ cells is about 2 hours.

2. Probably only a single polar body is formed which lies close to the dorso-lateral surface of the anterior third of the egg. Fertilization probably occurs immediately after maturation.

3. There are 8 or 9 cell divisions prior to peripheral investment; the first five are synchronous or almost so, the others occurring at random.

4. Cleavage cells first attain the periphery in the anterior third of the egg at about the same horizontal plane as the original egg nucleus.

5. Primary yolk cells are formed from cleavage cells which have migrated almost to the periplasm and have returned into the yolk.

6. The egg is of the determinate type; the cleavage cells reach the posterior pole last where they enter into and absorb the oosome forming the anlage of the primordial germ cells.

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## NORTH AMERICAN DICTYNID SPIDERS: THE BENNETTI GROUP OF AMAUROBIUS

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This group of spiders, here designated as the *bennetti* group of *Amaurobius*, comprises those North American species which group around *Amaurobius bennetti* (Blackwall). In these species, the epigynum has a pair of large lateral lobes which converge posteriorly around a small ovoid median lobe. The male has three distinct spurs on the tibia of the palpus, at the distal end above. The more detailed characteristics of this group are as follows:

**Color:** Carapace yellowish to reddish brown, usually with the front and sides of head darkened, at least in the female. Chelicerae reddish brown to dark brownish black. Labium and endites yellowish to dark chestnut brown, with narrow whitish tips; sometimes shaded with dusky in the male. Sternum yellowish to reddish brown, sometimes shaded with dusky. Legs yellowish to sometimes shaded with dusky, especially in certain males. Palpi same color as legs proximally, but darker distally. Abdomen typically dark gray with a light gray pattern above, more or less as shown in figures 6 and 8. Venter faded, or more often marked with four longitudinal lines or bands of pale gray. Sometimes the abdomen is uniform gray or black, or nearly so. Spinnerets yellowish to dusky brown. Epigynum reddish brown.

**Structure:** These species are uniformly robust in general structure. They vary in length from about 8 mm. to more than 15 mm.

**Female:** Carapace, in outline, longer than wide, the ratio about 10:7; the posterior end is broadly and shallowly emarginate; the sides sub-parallel, being slightly convexly rounded; head wide, being about two-thirds the width of the thorax, the length of the head beyond the cervical indentations about half its width; cervical indentations moderate; head essentially "square" in front. In profile, the ventral line of the carapace is nearly straight, sometimes slightly undulate, with the posterior end rising slightly, and with a slight downward dip at the cervical indentation, in front of which it rises sharply to the margin of the clypeus; clypeus low, about vertical, one to two diameters of an anterior median eye in height; anterior eyes slightly protruding, above which the profile rises steeply through the posterior eyes, then becomes nearly level to the median furrow, being slightly convex along the top of the head and highest near the middle of the head; posterior declivity of moderate gradient, and occupying about two-fifths of the length of the carapace. The median depression is a short, deep, narrow groove. Eyes 8, in two rows; subequal, usually the a. s. eyes are largest and the p. m. eyes smallest. Eye area occupies about half the width of the head. Anterior eye row straight to slightly procurved; median eyes a radius, plus or minus, apart, one to two diameters from the side eyes. Posterior row slightly procurved, sometimes nearly straight; median eyes 1.5 to 2.5 diameters apart, 2.5 to 4.0 diameters from the side eyes.

The two lateral eyes on each side about a radius apart. Median ocular quadrangle wider behind than in front, about as long as the width behind.

Chelicerae stout, vertical, parallel; the exposed length is a little less than the width of both of them in front; they are subcontiguous for most of their length; cetal outlines, as seen from in front, nearly straight and parallel. As seen from the side, the anterior base of the chelicerae is strongly convex to strongly geniculate. Boss prominent, smoothly rounded. With a sharp ridge along the mesal corner behind. Fang groove with 4 or 5 teeth on the anterior margin, of which the next to the mesal tooth is the largest; with 3 or 4 teeth on the posterior margin, of which the mesal tooth is the largest. Fang short, stout, simple.

Sternum moderately small, ovoid, slightly truncate in front; sides rounded or undulate; widest at second coxae; pointed behind, barely separating hind coxae. Labium longer than wide; basal corners prominently excised; tip broadly emarginate. Endites stout, elongate, extending well beyond the labium; subparallel; slightly expanded distally; the antero-mesal corners slightly convergent, but not touching. Palpus moderately small and slender; normal; extending to about the distal end of patella 1; femur, tibia-patella, and tarsus all about equal in length; terminal claw prominent, toothed.

Legs essentially homogeneous, robust, without special modifications; 1 4 2 3 or 4 1 2 3 in order of length, but the size differences are not great; gradually tapering to distal end; spined. Calamistrum double, extending for about half the length of the metatarsus; metatarsus 4 is flattened on top above the calamistrum, and bears a thick growth of short, uniform hairs on the flattened part. Legs with a row of fine trichobothria on tarsi and metatarsi. The arrangement of the spines is shown by figure 5.

Abdomen simple, ovoid, widest near middle, more or less flattened on top; width about 0.6 of length, wider than high. Spinnerets 6, short, convergent at tips; anterior pair stoutest, about same length as posterior pair. Cribellum divided. The epigynum consists, superficially, of three lobes—a pair of large lateral lobes, which surround the small ovoid median lobe and come together posteriorly, where they are contiguous or nearly so. Ectad of each lateral lobe, on the posterior margin, is an excavation, with the anterior rim more or less chitinized. This excavation is commonly filled with solid extraneous material. On the posterior face of the epigynum (hidden in the furrow) is a small median sclerite. The openings are concealed between the lateral and median lobes; the large spermathecum is contained in the lateral lobe.

*Male:* Compared to the female, the male exhibits the following differences: Carapace with the head narrower and shorter, width only little more than half that of the thorax; median depression larger; posterior declivity occupying only about a fourth of the length. Eyes closer together, the distances between them approaching the minimum distances given for the female. Chelicerae not so robust. Legs longer and often more slender in proportion to length; spines more numerous, with fewer reductions on legs 1 and 2. The calamistrum is much reduced, or nearly absent, as is also the flattened area on the dorsal side

of the metatarsus with its covering of short hairs. Abdomen much smaller. Palpus moderately stout. Femur and patella not modified. Tibia short and stout, broadened anteriorly, with three conspicuous spurs visible from the dorsal aspect, these directed in general distad. Tarsus moderately small and short; cymbium somewhat triangular. The palpal organs are compact; there are three separate sclerites—a subtegulum; a tegulum, to which the short stout embolus is fused; and a well developed median apophysis. A membranous lamella arises from the center of the tegulum, distally. Structure of the palpal organs show but slight variation in the different species.

*Setae*: Aside from the movable spines on the legs and palpi, the entire body is covered with large slender bristles, with a more dense underlying cover of short fine hairs. At no place is the covering sufficiently dense as to conceal the integument. There are no well-developed scopulae, except the brush at the meso-distal end of the endites. There is a fringe of coarse hairs anterior to the fang on the chelicerae. The setae on the tarsi of the legs form a dense short covering, especially on the under side; but these are not formed into scopulae.

*Phylogeny*: While there is some doubt as to the phylogenetic relationships of some of the species, especially those for which adults or males are not known, figure 1 indicates a scheme of the approximate phylogeny within this group.

*Procedure*: The species are listed alphabetically, regardless of their relationships. The descriptions contain only a few of the more essential characters and omit much that is common to all the species. The localities are listed in units of one degree longitude by one degree latitude; the co-ordinates of the southeast corner of the quadrangle are given, longitude first, separated from the latitude by a period. The records are based mostly on published reports and the material in the University of Utah Collection. Some of the material from the American Museum of Natural History is also recorded, including the types of eight of the new species. This latter material was made available through the generous co-operation of Dr. Willis J. Gertsch.

#### KEY TO SPECIES

The North American species may be separated by means of the following key, with certain reservations. Some of the species are not represented by adults of one or both sexes and have had to be omitted. The spines are used extensively in the females, as they show considerable variation, and constitute definite, concise characters. But the spines are frequently erratic within a species, and often the two sides of the same individual are not the same. While each species has a typical arrangement, a number of individual exceptions occur. This key attempts to include the more common exceptions, where known, but cannot include all the rare cases. Nevertheless, it should be fairly reliable in tracing down the species included herein.

1. Females<sup>1</sup>  
Males<sup>2</sup>.

<sup>1</sup>The females of *alaskanus*, *angelus*, and *pallescens* are omitted from this key, since they are unknown to us.

<sup>2</sup>The males of the following species are unknown or not at hand, and are not included in this key: *arizonicus*, *catalinus*, *kamelus*, *melanus*, *nomeus*, *pallescens*, *severinus*, *shastus*, and *subnomeus*.

2. Metatarsus 1 with only one ventral spine at distal end (three spines visible at distal end from below)..... 3
- Metatarsus 1 with two ventral spines at distal end (four spines visible at distal end from below)..... 11
3. Metatarsus 1 with only two spines near the base as seen from below..... 4
- Metatarsus 1 with 3 or 4 spines near base visible from below..... 9
4. Patella 3 with a spine on the anterior side..... 5
- Patella 3 without a spine on the anterior side..... 7
5. Anterior median eyes slightly larger than the posterior median eyes... *pictus*
- Anterior median eyes slightly smaller than the posterior median eyes..... 6
6. Epigynum with a conspicuous raised ridge, extending anteriorly along the mesal edge of each lobe; posterior ectal corner not angulate (see fig. 21)..... *kamelus*
- Epigynum without such a ridge; posterior ectal corner angulate as seen from ventral view (see fig. 19)..... *tamarus*
7. Femur 3 with a small median spine at distal end above..... 8
- Femur 3 without a median distal spine..... *nomeus*
8. Abdomen dense black..... *melanus*
- Abdomen gray, with a dorsal pattern of pale gray..... *subnomeus*
9. Middle lobe of epigynum about half as wide as a lateral lobe; eastern North America..... *bennetti*
- Middle lobe of epigynum distinctly less than half the width of a lateral lobe; western North America..... 10
10. Length more than 12 mm..... *nevadensis*
- Length less than 12 mm..... *tamarus*
11. Metatarsus 1 with only two spines near base as seen from below..... 12
- Metatarsus 1 with three or four spines near base as seen from below..... 17
12. Epigynum with posterior median sclerite (hidden in furrow) very small and inconspicuous..... *severinus*
- Epigynum with posterior median sclerite large and conspicuous, triangular or pentagonal..... 13
13. Epigynum with the middle lobe (as seen from ventral view) nearly as wide as long..... 14
- Epigynum with middle lobe decidedly longer than wide, usually twice as long..... 15
14. Dorsal pattern of abdomen conspicuous..... *arizonicus*
- Dorsal pattern of abdomen obscure..... *olympus*
15. Epigynum with a secondary lobe ectad of the main lateral lobe and separated from it by a deep notch..... *deces*
- Epigynum without a secondary lateral lobe..... 16
16. Anterior median eyes nearly a diameter apart..... *catalinus*
- Anterior median eyes only a radius or slightly more apart..... *shastus*
17. Length more than twelve millimeters..... 18
- Length less than twelve millimeters..... 19
18. Posterior face of epigynum (which is hidden in the furrow) with the ectal part broadly excavated, and with the median sclerite very small and inconspicuous..... *severus*
- Posterior face of epigynum with the ectal part not broadly excavated, and with the median sclerite large and sub-triangular..... *nevadensis*
19. Patella 3 with a spine on the anterior side..... *canada*
- Patella 3 without an anterior spine..... 20
20. Anterior median eyes slightly larger than the posterior median eyes; epigynum broadly excavated behind..... *severinus*
- Anterior median eyes not larger than the posterior median eyes; epigynum not broadly excavated behind..... *enus*
21. Tibia of palpus with the mesal spur shorter than the middle spur.... *pictus*
- Mesal spur longer than the middle spur..... 22
22. Mesal spur less than twice as long as the middle spur..... *tamarus*
- Mesal spur at least twice as long as the middle spur..... 23
23. Sides of head conspicuously reticulated with dusky..... 24
- Sides of head not reticulated with dusky..... 28
24. Palpus with mesal spur of tibia straight distally for most of its length..... 25
- Palpus with mesal spur of tibia more or less curved distally..... 27

25. Middle spur of tibia obliquely truncate at distal end.....*deces*  
Middle spur of tibia more or less conical in shape.....26
26. Tibia of palpus with the middle spur more rounded at tip; mesal spur with a more conspicuous double curve along the mesal edge; eastern North America (See fig. 13).....*bennetti*  
Tibia of palpus with the middle spur more acute at tip; mesal spur with the mesal edge nearly straight; western North America (See fig. 14).....*enus*
27. Palpus with mesal spur of tibia tapering to a needle-like point.....*canada*  
Palpus with the mesal spur of the tibia remaining relatively uniform in thickness to near the tip, then coming to a point quickly.....*tacoma*
28. Tibia of palpus with the distance from the bottom of the notch between the middle and mesal spurs to the tip of the mesal spur much greater than the distance from the tip of the middle spur to the base of the tibia.....29  
Tibia of palpus with these distances about equal or the latter greater.....30
29. Tibia of palpus with the middle lobe short and situated on the base of the mesal spur.....*angelus*  
Tibia of palpus with the middle lobe large and distinctly separated from the mesal spur.....*olympus*
30. Tibia of palpus with the middle spur double; mesal spur short, slender, and curved near tip.....*alaskanus*  
Tibia of palpus with middle spur single; mesal spur stout at base and tapering to a sharp, nearly straight tip.....31
31. Middle spur of tibia of palpus simple, distal end rounded; mesal spur bent toward a line extended from the median point of the patella through the tip of the middle spur of the tibia.....*nevadensis*  
Middle spur of tibia of palpus obliquely truncate or with the distal margin concave; mesal spur not bent toward a line extended from the median point of the patella through the tip of the middle spur of the tibia... *severus*

### *Amaurobius alaskanus* new species

#### Figure 31

Badly damaged male.

*Color:* Probably about typical. Legs lightly annulated. Front of head and chelicerae dark reddish brown. (Abdomen missing from type).

*Structure:* Posterior eye row procurved. Posterior median eyes a little more than 2 diameters apart, nearly 3 diameters from the side eyes. Tibia of palpus distinctive. The middle lobe is split into two distinct small lobes. Mesal lobe short, with distal half slender and of about uniform thickness, strongly curved.

Carapace 3.85 mm. long, 3.25 mm. wide.

*Type locality:* "Alaska" (no further data). ♂ Holotype in collection of the American Museum of Natural History.

### *Amaurobius angelus* new species

#### Figure 29

Male.

*Color:* Carapace orange brown; head slightly reticulated on the sides. Chelicerae dark reddish brown. Labium and endites reddish brown. Sternum, legs and palpi light brownish yellow. Abdomen gray; the dorsal pattern obscure.

*Structure:* Evidently related to *olympus*. The palpus has a similar long mesal process on the tibia, but the middle lobe is located on the base of the mesal process, instead of appearing as a distinct lobe.

*Measurements:* ♂ Holotype.

		♂ Holotype	
		Mm.	Ratio
Length....		9.60	200
Carapace:			
Length....		4.80	100
Width.....		3.47	72
Tibia-patella:			
1.....		5.20	108
4.....		4.93	103

*Type locality:* Quadrangle W. 118° : N. 34°, "Los Angeles, California" (no further data). ♂ holotype in Collection of American Museum of Natural History.

### **Amaurobius arizonicus** new species

Figure 33

#### **Female.**

*Color:* Carapace light brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites reddish brown. Legs and palpi light brownish yellow, the palpi reddish brown distally. Abdomen gray, with a distinct light gray pattern on dorsum.

*Structure* essentially typical, with minor distinctions in the epigynum and spines. The posterior face of the epigynum is excavated ectally; the median lobe is much longer than wide; the lateral lobe bears a small raised angle at distal end. Eye rows slightly procurved. The a. m. eyes are about 0.7 diameters apart, 1.8 diameters from the side eyes. The p. m. eyes are nearly 2.0 diameters apart, about 3.0 diameters from the side eyes. The more significant spine variations are these:

Tibia 1 with one or two spines on anterior face.

Metatarsus 1 with two ventral spines at distal end; with only two spines near base.

Patella 3 without an anterior spine. (One exception noted.)

Femur 3 without a median distal spine. (One exception noted.)

Metatarsus 4 without a median spine near base. (One exception noted.)

#### *Measurements:*

	♀ 1	♀ 2	♀ 3	Average	Ratio
Length.....	12.30	11.00	16.00	13.10	250
Carapace:					
Length.....	4.80	4.53	6.40	5.24	100
Width.....	3.20	3.07	4.26	3.51	67
Tibia-patella:					
1.....	4.07	4.60	6.40	5.36	102
4.....	4.96	4.40	6.40	5.25	100

*Type locality:* Quadrangle W. 109° : N. 33°, Arizona. 17 miles N. E. Whiteriver, White Mountains; July 8-10, 1940; ♀ holotype, 4 ♀ paratypes; Gertsch and Hook collectors. Two ♀ paratypes in University of Utah Collection; others in American Museum.

*Other Locality:* Quadrangle W. 109° : N. 32°, Arizona. Graham Mt.; Sept. 10, 1937; ♀ paratype; Owen Bryant. (American Museum.)

**Amaurobius bennetti** (Blackwall)

Figures 13, 22

- Ciniflo bennetti* Blackwell, 1846, *Ann. & Mag. Nat. Hist.*, 17: 41.  
*Amaurobius sylvestris* Emerton, 1888, *Trans. Conn. Acad. Sci.*, 7: 451; \*10: 1.  
*Amaurobius sylvestris* Banks, 1892, *Proc. Acad. Phila.*, 20.  
*A. bennetti* Banks, 1895, *Journ. New York Ent. Soc.*, 3: 82.  
*A. sylvestris* Emerton, 1902, *Common Spiders*, 213; \*489-490.  
*A. sylvestris* Simon, 1903, *Bull. Mus. Paris*, 9: 386.  
*A. bennetti* Banks, 1910, *Bull. U. S. Nat. Mus.*, No. 72: 18.  
*A. bennetti* Petrunkevitch, 1911, *Cat. Spid. Amer.*, 104.  
*A. bennetti* Comstock, 1912, *Spider Book*, 277; \*255-257.  
*A. bennetti* Emerton, 1919, *Trans. Royal Canadian Inst.*, 12: 324.  
*A. bennetti* Kaston, 1938, *Conn. Geol. & Nat. Hist. Surv.*, Bull. 60: 181.  
*A. bennetti* Truman, 1942, *Proc. Penn. Acad. Sci.*, 16: 27.

**Color:** Essentially typical, with minor modifications. Carapace of male has more or less distinct radial streaks and the sides of the head are reticulated. Sternum darkened, dusky brown in the male. Abdomen with the spots of the dorsal pattern usually coalesced into one large complex mark; the sides usually speckled with light gray; the venter usually marked with longitudinal bands of light gray, rather than merely faded.

**Structure:** Size medium to small for this group. Legs only moderately robust. Eye rows slightly procurved. Anterior median eyes of female about a radius apart, 1.50 to 1.75 diameters from the side eyes. Posterior median eyes about 2 diameters apart, 3.5 to 4.0 diameters from the side eyes. Eyes of male closer together. Median ocular quadrangle about as wide behind as long. Epigynum typical; posterior ectal corners rounded. Male palpus with the mesal spur of the tibia long and pointed, the middle spur rounded at tip, and the ectal spur with the pointed tip bent sharply mesad. The spines on the legs of the female show the following variations:

Tibia 1 with one to three spines on anterior face.

Metatarsus 1 with one distal ventral spine, and with lateral spines near base on one or both sides.

Femur 3 without a median distal spine.

Patella 3 with or without an anterior spine.

Metatarsus 4 without a dorsal median spine near base, except rarely.

**Measurements:**

	♂		♀	
	Mm.	Ratio	Mm.	Ratio
Length.....	8.60	181	10.00	222
Carapace:				
Length.....	4.75	100	4.50	100
Width.....	3.45	73	3.07	68
Tibia-patella:				
1.....	5.20	109	3.95	88
4.....	5.10	107	3.80	84

**Type locality:** About W. 79° 28' : N. 43° 40', Ontario, near Toronto; 1840; Potter. (After Emerton, 1919.)

**Known localities:** Newfoundland. (Emerton, 1919). 62.49, Island



Anticosti. (Petrunkévitch, 1911). 63.42, 4 ♀, Nova Scotia: Truro. Nova Scotia. (Emerton, 1919). 70.43, ♀, Maine: N. W. Wells; August 12, 1933; Wilton Ivie. 71.46, Quebec: Quebec. (Emerton, 1919). 71.44, New Hampshire: White Mts. (Emerton, 1888). 71.42, ♂, Massachusetts: Blue Hills (72.41), Connecticut. (Kaston, 1938). New England: "All over." (Emerton, 1888). 73.41, ♀, Connecticut: Norwalk; July 2, 1933; W. Ivie. 74.42, ♂, New York: Mt. Garfield. 74.41, 3 ♀, New York: Sterlington. 76.42, New York: vicinity Ithaca. (Banks, 1892). 76.42, 2 ♀, New York: Ithaca. 77.42, 4 ♀, New York: Wallace; June 19, 1933; W. Ivie. 79.43, Types, Ontario: Toronto; 1940; Potter. Type locality. 79.40, Pennsylvania: Presque Island. (Truman, 1942). 80.46, ♀s, Ontario: Island 1024, Lake Temagami; Aug. 15-25, 1946; Gertsch, Ivie, and Kurata. 82.41, ♀, Ohio: Put-in-Bay, Lake Erie; Aug. 16, 1935; W. Ivie. 82.39, 2 ♀, Ohio: Cantwell Cliffs; July 27, 1935; Barrows and Ivie. 82.36, ♀, Tennessee: Erwin; July 8, 1933; Wilton Ivie. 83.35, ♀, Tennessee: Little Pigeon Cr.; July 9, 1933; W. Ivie. 86.38, ♀, Indiana: Smith Woods, N. E. Springfield; Oct. 13, 1940; W. J. Beecher. 87.39, ♀, Indiana: Annapolis; Oct. 21, 1940; R. L. Wetzel. 90.46, Im., Wisconsin: Kimball; July 2, 1910; R. V. Chamberlin. 93.42, ♀, Iowa: Mongoina to Boone; June 23, 1910; R. V. Chamberlin. 94.49, Ontario: Minaki. (Emerton, 1919). 96.50, Manitoba: Lake Winnipeg. (Emerton, 1919).

### *Amaurobius canada* new species

Figures 28, 34

**Color:** Carapace light brown, female with front of head darker, male with head reticulated and with thorax marked with three pairs of dusky wedges. Chelicerae reddish brown in male, dark chestnut in female. Labium and endites dark reddish brown, with narrow whitish tips, in female; light brown shaded with dusky in male. Sternum orange brown in female, dusky brown in male. Abdomen gray, with dorsal pattern moderately distinct in female; darker, with dorsal markings obscure, in male.

**Structure** essentially typical. Evidently near to *deces* and *enus*. Male: Eye rows faintly procurved. A. m. eyes 0.8 diameter apart, 1.8 diameters from the side eyes. P. M. eyes 1.8 diameters apart, 2.3 diameters from the side eyes. Palpus very similar to those of *enus* and *bennetti*, but the ectal edge of the mesal process is more curved.

Female: Anterior median eyes 0.9 diameter apart, 2.5 to 3.0 diameters from the side eyes. Epigynum with the middle lobe about as wide as long; lateral lobes with a tiny secondary lobe on ectal side at base. Spines of legs modified as follows:

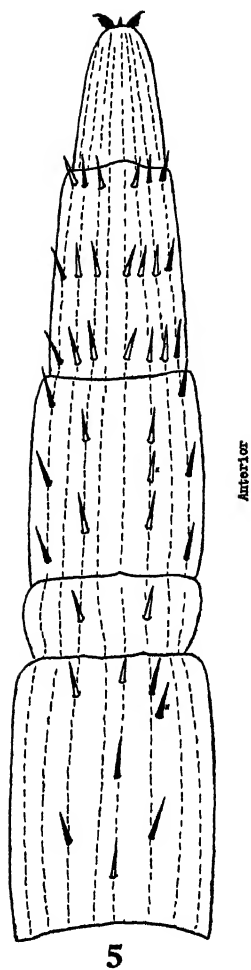
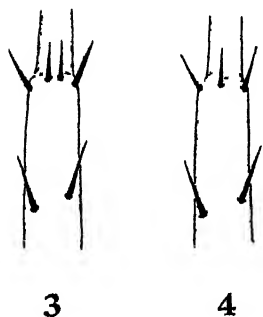
Tibia 1 with 3 spines on anterior face.

Metatarsus 1 with two ventral spines at distal end, and with one or two lateral spines near base, besides the two ventral spines.

Patella 3 with an anterior spine.

Femur 3 with a distal median spine.

Metatarsus 4 with a median spine near base above.



- ♣ Usually on all legs of all species
- ♣ Usually on leg 3 of all species; often absent from other legs
- ♣ Present in some species, absent in others
- ♣\* Present only on leg 1, or occasionally on leg 2

37

*Measurements:*

	♂ Holotype		♀ Allotype	
	Mm.	Ratio	Mm.	Ratio
Length.	9 60	200	12 00	214
Carapace:				
Length	4 80	100	5 60	100
Width	3 25	68	3 73	67
Tibia-patella				
1	5 35	111	5 23	93
4	5 35	111	5 06	90

*Type locality:* Quadrangle W. 119° : N. 50°, British Columbia. Salmon Arms; ♂ holotype, ♀ and immature paratypes, May, 1910, ♀ allotype, May, 1941, ♂ paratype, October, 1939; Olive R. Leach collector. ♂ ♀ paratypes in University of Utah, others in American Museum.

*Other localities:* 122.45, ♀, Oregon: Multnomah Falls; July 4, 1912; Borys Malkin. (American Museum). 121.44, ♀, Oregon: Warm Springs; July 7, 1944, Roger Tecl. (American Museum).

***Amaurobius catalinus* new species**

## Figure 35

*Color:* Carapace brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites dark reddish brown. Sternum yellowish brown, lightly shaded with dusky. Legs and palpi yellowish brown, with the tibia and tarsus of palpus reddish brown. Abdomen dark gray, with a conspicuous pattern of pale gray above. Spinnerets and epigynum orange brown.

*Structure:* Size medium to large for this group. Posterior eye row straight or slightly procurved. A. m. eyes 0.8 diameter apart, 1.7 diameters from the side eyes. P. m. eyes 1.8 diameters apart, 2.8 diameters from side eyes. Epigynum simple, rounded; without secondary lobes or processes; middle lobe nearly as wide as long. Spines of legs modified as follows:

Femur 1 lacking distal spine on posterior side.

Tibia 1 with one or two spines on anterior face.

Metatarsus 1 with two ventral spines at distal end, and without lateral spines near base.

Patella 3 usually without an anterior spine.

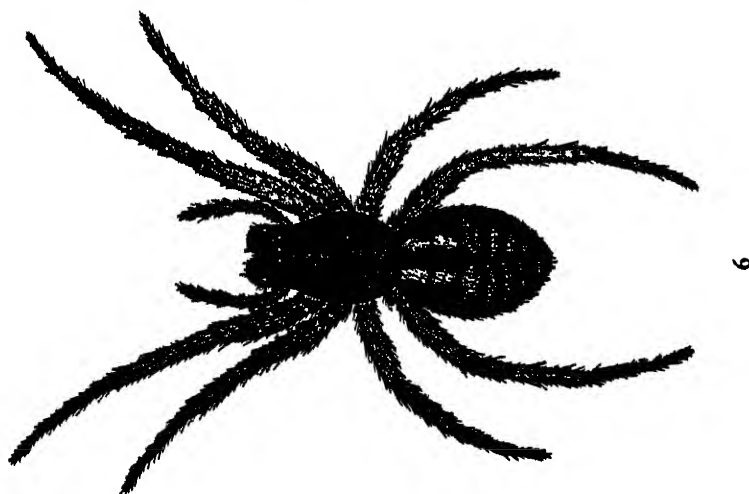
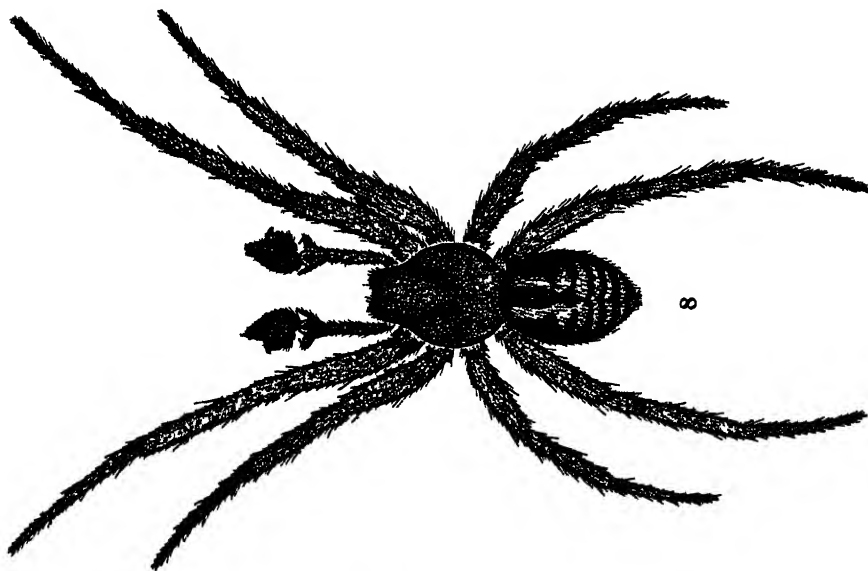
Metatarsus 4 without a median dorsal spine at base.

*Measurements:*

	♀ 1	♀ 2	♀ 3	Average	Ratio
Length.	10 00	11 00	10 80	10 60	203
Carapace:					
Length	5 05	5 10	5 47	5 21	100
Width.	3 34	3 47	3 63	3 46	66
Tibia-patella:					
1	4 43	4 55	4 88	4 62	89
4	4 60	4 60	4 88	4 69	90

## EXPLANATION OF PLATE II

6. *Amaurobius tamarus* new species, female. 7. Same, ventral view of body of female. 8. Same, male.



*Type locality:* Quadrangle W. 110°:N. 32°. Arizona: Soldiers Camp, Bear Wallow Station, Catalina Mts; ♀ holotype, 2 ♀ paratypes. One ♀ paratype in University of Utah Collection, the others in the American Museum Collection.

### **Amaurobius deces** new species

Figures 24, 30

*Color:* ♀ Carapace orange brown, darker on the head. Chelicerae dark chestnut brown. Labium and endites dark reddish brown, with narrow whitish tips. Sternum light brown, lightly shaded with dusky. Legs yellowish brown. Abdomen dark gray, with dorsal pattern usually distinct, usually made up of separate spots; venter mostly dark gray, with the light gray forming into four more or less distinct longitudinal lines or bands.

♂. Carapace light brown, with sides of head and thorax reticulated with dusky, and with dusky radial streaks. Chelicerae reddish brown. Labium and endites dusky brown. Sternum dark dusky brown. Legs and palpi light brown, shaded with dusky. Abdomen as in female, but averages darker.

*Structure:* ♂. Eye rows procurved. A. m. eyes 1.0 diameter apart, 1.5 diameter from the side eyes. P. m. eyes about 2.0 diameters apart, about 3.0 diameters from the side eyes. Structure otherwise typical, except for minor differences in the tibia of the palpus. The mesal process of the palpus is straight and sharp pointed; the middle lobe is broad and obliquely truncate.

♀. Anterior median eyes about 0.8 diameter apart, 1.7 diameters from the side eyes. Posterior median eyes about 2.0 diameters apart, or slightly less, about 3.6 diameters from the side eyes. Epigynum with a distinct lobe on the rim ectad of the lateral lobes. The spines on the legs show the following more significant variations:

Tibia 1 with 1, 2, or 3 spines on the anterior face, usually 2.

Metatarsus 1 with two ventral spines at distal end, without lateral spines near base.

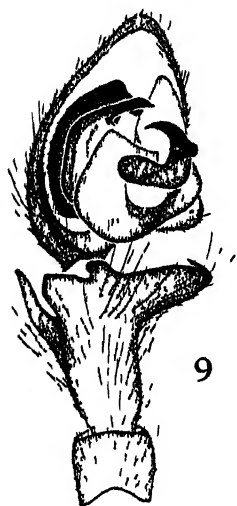
Femur 3 usually with a distal median spine.

Patella 3 usually without an anterior spine.

Metatarsus 4 usually without a median dorsal spine near base

### EXPLANATION OF PLATE III

9. *Amaurobius tamarus* n. sp., ventral view of male palpus. 10. Same, dorsal view of tibia of palpus. 11. *Amaurobius nomeus* Chamberlin, dorsal view of tibia of palpus. (After Chamberlin.) 12. *Amaurobius pictus* Simon, dorsal view of tibia of palpus. 13. *Amaurobius bennethi* (Blackwall), dorsal view of tibia of palpus. 14. *Amaurobius enus* n. sp., dorsal view of tibia of palpus. 15. *Amaurobius olympus* n. sp., dorsal view of tibia of palpus. 16. *Amaurobius nevadensis* Simon, dorsal view of tibia of palpus. 17. *Amaurobius severus* Simon, dorsal view of tibia of palpus.



10

11



12



13



14



15



16



17

*Measurements:*

	$\sigma$		$\varphi$ s (5)	
	Mm.	Ratio	Mm.	Ratio
Length	8 00	188	9 46	200
Carapace				
Length	1 26	100	1 72	100
Width	3 07	72	3 13	66
Tibia-patella.				
1	1 42	101	4 05	86
4	1 32	101	1 04	86

*Type locality:* W 123° 2' . N 44° 10' Oregon: Coburg Hills, 3 miles N. E Coburg, March 22, 1942; Borys Malkin and Harold Stobie;  $\sigma$  holotype,  $\varphi$  allotype, 2 $\sigma$  5 $\varphi$  paratypes.  $\sigma$  2 $\varphi$  paratypes in University of Utah Collection, others in American Museum Collection.

*Known localities:* 123 45,  $\varphi$ , Oregon: 5 mi. So. Forest Grove; November 28, 1940; Wilton Ivic. (U. U.) 123.44, 3 $\sigma$  6 $\varphi$ , Type locality. 123.44, 2 $\varphi$ , Oregon: Salem, March, 1940; J. C. Chamberlin. (U. U.) 123.44, 4 $\varphi$ , Oregon: Spencer's Butte, Eugene; March 29, 1942; Borys Malkin and John Sadler (2 $\varphi$ -U. U., 2 $\varphi$ -A. M.) 123 44,  $\sigma$  3 $\varphi$ , Same; April 26, 1942; Borys Malkin. (A. M.) 123 41, 2 $\varphi$ , Oregon: Eugene; March 19, 1942; Borys Malkin. (A. M.)

***Amaurobius enus* new species**

Figures 14, 23

*Color* essentially typical, with these modifications: Carapace of male with fine reticulate markings on the head and sides, and with dusky radial streaks. Sternum of male dusky; normal, or slightly darkened, in female. Legs of male more or less shaded with dusky, with two pale stripes on dorsal side of each tibia. Dorsal pattern of abdomen usually obscure or absent; when present, it is usually in the form of two irregular parallel bands extending the full length of the abdomen.

*Structure:* Both eye rows slightly procurved. Anterior median eyes about the same size as the posterior medians. A. m. eyes a little more than a radius apart, about two diameters from the side eyes. P. m. eyes a little less than 2 diameters apart, 3.5 to 4.0 diameters from the side eyes. Median ocular quadrangle about as wide behind as long. Epigynum similar to that of *bennetti*, but the posterior margin usually more smoothly rounded. The palpus is very close to those of *bennetti* and *canada*. The mesal spur of the tibia is a little longer than in *bennetti*, is pointed more directly forward, and the mesal margin is less undulate. The mesal spur is straighter than that of *canada*. The more significant spine variations on the legs of the female are as follows:

**EXPLANATION OF PLATE IV**

18. *Amaurobius nomeus* Chamberlin, epigynum. 19. *Amaurobius tamarus* n. sp., epigynum. 20. *Amaurobius pictus* Simon, epigynum. 21. *Amaurobius kamelus* n. sp., epigynum. 22. *Amaurobius bennetti* (Blackwall), epigynum. 23. *Amaurobius enus* n. sp., epigynum. 24. *Amaurobius deces* n. sp., epigynum. 25. *Amaurobius olympus* n. sp., epigynum. 26. *Amaurobius nevadensis* Simon, epigynum. 27. *Amaurobius severus* Simon, epigynum.



18



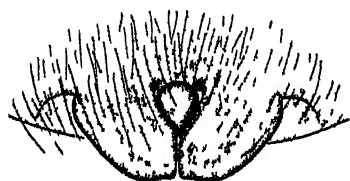
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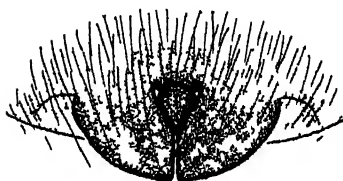
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21



22



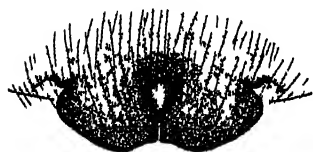
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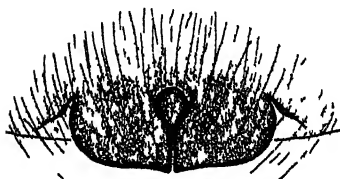
24



25



26



27



Femur 1 lacks a distal spine on the posterior side.

Tibia 1 has three spines on the anterior face, above the ventral spines.

Metatarsus 1 with two ventral spines at distal end, with one or two lateral spines near base, and with a distal spine on the anterior corner above.

Femur 3 lacks a median distal spine.

Patella 3 lacks a spine on the anterior side.

Metatarsus 4 lacks a median dorsal spine near the base.

#### Measurements:

	♂		♀	
	Mm.	Ratio	Mm.	Ratio
Length	8 20	178	11 30	210
Carapace:				
Length	4 60	100	4 70	100
Width	3 25	71	3 20	68
Tibia-patella:				
1	1 60	100	3 80	81
4	1 70	102	4 00	85

*Type locality:* W.  $116^{\circ} 2'$  : N.  $44^{\circ} 56'$ . Idaho: 3 miles N. E. of McCall; ♂ holotype, ♀ allotype, ♂ ♀s paratypes, May 31, 1911; ♂s ♀s paratypes, April 28, 1945 (the males were not mature, but were kept alive and matured within two weeks); Wilton Ivie.

*Other localities:* Quadrangle W.  $116^{\circ}$  : N.  $44^{\circ}$ . Idaho: Lost Lake; upper Weiser River; etc ; various dates; many ♀s paratypes; Wilton Ivie

Types in Collection of University of Utah; ♂s ♀s paratypes in American Museum.

*Habitat:* Lives mostly in rotten logs in pine woods; also found under pieces of bark, wood, etc., on the ground; and in crevices of trees and buildings. The habitat is very similar to that of *bennetti* in the east.

#### *Amaurobius kamelus* new species

Figure 21

Female.

*Color* typical. Pattern on abdomen moderately well developed.

*Structure* essentially typical, with minor modifications. Anterior median eyes smaller than the others. Posterior eye row straight; anterior row faintly procurved. Anterior median eyes about 0.7 diameter apart, about 2.0 diameters from the side eyes. P. m. eyes about 1.8 diameters apart, about 3.0 diameters from the side eyes. Chelicerae

#### EXPLANATION OF PLATE V

28. *Amaurobius canada* n. sp., dorsal view of tibia of left palpus. 29. *Amaurobius angelus* n. sp., dorsal view of tibia of left palpus. 30. *Amaurobius decei* n. sp., dorsal view of tibia of left palpus. 31. *Amaurobius alaskanus* n. sp., dorsal view of tibia of left palpus. 32. *Amaurobius tacoma* n. sp., dorsal view of tibia of left palpus. 33. *Amaurobius arizonicus* n. sp., epigynum. 34. *Amaurobius canada* n. sp., epigynum. 35. *Amaurobius californicus* n. sp., epigynum. 36. *Amaurobius severinus* n. sp., epigynum. 37. *Amaurobius olympus* n. sp., epigynum of another specimen.



28



29



30



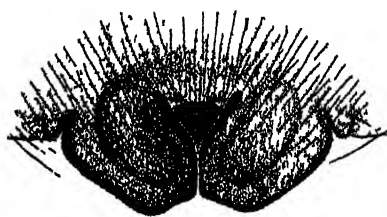
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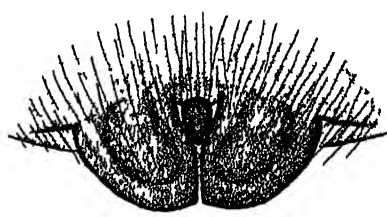
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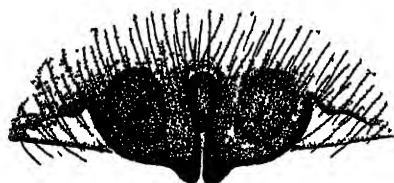
33



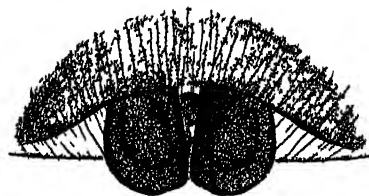
34



35



36



37

with 3 teeth on posterior margin of the fang groove. The epigynum shows a peculiar modification in that the mesal side of the lateral lobe is elevated into a rounded ridge, which extends anteriorly. The leg spines show the following variations:

Femur 1 without a distal spine on the posterior side.

Metatarsus 1 with one distal ventral spine, without lateral spines near base.

Patella 3 with a spine on the anterior side.

Metatarsus 4 without a median dorsal spine near base.

*Measurements:*

	♀ Holotype		♀ Paratype	
	<i>Mm.</i>	<i>Ratio</i>	<i>Mm.</i>	<i>Ratio</i>
Length.....	9.20	230	10.00	210
Carapace:				
Length.....	4.00	100	4.80	100
Width.....	2.67	67	3.20	67
Tibia-patella:				
1.....	3.67	92	4.30	90
4.....	3.60	90	4.20	87

*Type locality:* W. 118° 28' : N. 45° 28'. Oregon: Meacham Lake, Blue Mts.; ♀ holotype, ♀ paratype; July 4, 1938; Wilton Ivie collector. Found under stones near the bottom of a shady ravine. (University of Utah.)

***Amaurobius melanus* new species**

Immature.

*Color* dark. Carapace dull, dark brown. Chelicerae dark chestnut brown. Labium and endites reddish brown. Sternum dusky brown, paler in the middle. Legs brown. Abdomen entirely dense black.

*Structure* essentially typical. The leg spines show the following modifications:

Metatarsi 1 and 2 have only one distal ventral spine.

Femur 3 with or without distal median spines, without lateral spines near base.

Patella 3 without a spine on the anterior side.

*Type locality:* W. 121° 55' : N. 36° 38'. California: Pacific Grove; September 1, 1937; immature holotype, immature paratype; Wilton Ivie collector.

This species is evidently closely related to *subnomeus*, but is distinguishable from that and the other species by its dense black abdomen. While *nevadensis*, *olympus*, *severus*, and perhaps one or two others may occasionally have a black abdomen in old females, none of them has it in the immature form.

***Amaurobius nevadensis* Simon**

Figures 16, 26

*Amaurobius nevadensis* Simon, 1884, *Bull. Soc. Zool. France*, 9: 318; \*1.

*A. nevadensis* Banks, 1904, *Proc. Calif. Acad. Sci.*, (3)3: 341.

*A. nevadensis* Petrunkevitch, 1911, *Cat. Spid. Amer.*, 104.

*Amaurobius utahensis* Chamberlin, 1919, *Ann. Ent. Soc. Amer.*, 12: 239.

*Color* typical. Front and sides of head often blackened in the females. Dorsal pattern of abdomen conspicuous in the males and immature, but tends to become obscured or even absent in the adult females.

*Structure:* Large and robust. Both eye rows slightly procurved. A. m. eyes in the female a little larger than the p. m. eyes, or about the same size. A. m. eyes about a radius apart, about two diameters from the side eyes. P. m. eyes about two diameters apart, about 4 diameters from the side eyes. The principal variations in the leg spines of the females are these:

Femur 1 usually without, occasionally with, a distal posterior spine.

Tibia 1 with 1 or 2 spines on anterior face.

Metatarsus 1 with two ventral spines at distal end below (occasionally only one), with one or two lateral spines near base, at least on one side of spider.

Femur 3 without a median distal spine.

Patella 3 with or without an anterior spine.

Metatarsus 1 without a median dorsal spine near base.

*Measurements:*

	♂		♀	
	<i>Mm.</i>	<i>Ratio</i>	<i>Mm.</i>	<i>Ratio</i>
Length....	11.70	188	15.00	227
Carapace:				
Length...	6.20	100	6.60	100
Width.....	4.53	73	4.50	68
Tibia-patella:				
1.....	7.15	115	6.67	101
4.....	7.20	116	6.52	99

*Type locality:* "Nevada."

*Known localities:* 111.41, ♀, Utah: Ogden Canyon; May 7, 1927; R. V. Chamberlin. 111.40, 4♂ 4♀, Utah: Hughes Canyon, near Holaday; May 30, 1934; W. Ivie. 111.40, ♂s ♀s, Utah: Many localities in Wasatch Mts.; various dates. 112.38, ♂, Utah: Fillmore; August, 1917; R. V. Chamberlin. (Chamberlin, 1919; type of *A. utahensis*. M. C. Z.) 119.39, 3♀, Nevada: Reno; Jan. and July, 1940; University of Nevada. 119.37, California: Pine Ridge; Clark. (Banks, 1904.) 119.37, ♂ 4♀, California: Aspen Valley, Yosemite Park; August 11, 1931; Wilton Ivie. 119.37, ♀, California: Mammoth Lakes; August 18, 1941; W. M. Pearce. (American Museum.) 120.39, California: Sierra Co.; Fuchs. (Banks, 1904.) 120.39, 2♀, California: Emigrant Gap; August 23, 1932; S. D. Durrant. 120.39, ♀, Same; July 16, 1937; R. V. Chamberlin. 120.38, 4♀, California: near Riverton; July 15, 1934; Wilton Ivie and Herman A. Rasmussen. 121.36, ♀, California: Pacific Grove; August 5, 1931; R. V. Chamberlin. 122.42, ♀, Oregon: Pinehurst; September 9, 1935; R. V. Chamberlin and Wilton Ivie. 122.41, 4♀, California: Weed; September 8, 1935; R. V. Chamberlin and Wilton Ivie. 122.38, California: Marin County; Vaslit. (Banks, 1904.)

**Amaurobius nomeus Chamberlin**

Figures 11, 18

*Amaurobius nomeus* Chamberlin, 1919, *Ann. Ent. Soc. Amer.*, 12: 240; \*14: 1-2.  
*A. nomeus* Gertsch & Jellison, 1939, *Amer. Mus. Novitates*, 1032: 2.

**Color:** Brighter than usual, as in *pictus*. The front and sides of the head in the female conspicuously darkened. Sternum lightly shaded with dusky. Legs without traces of annuli (present in *pictus*). Abdomen with the light markings large and distinctive.

**Structure:** Both eye rows of female procurved. A. m. eyes fully as large as the p. m. eyes or larger, about a radius apart, a little more than a diameter from the side eyes. P. m. eyes nearly two diameters apart, about 2.5 diameters from the side eyes. Median ocular quadrangle wider behind than long. The more significant spine modifications are as follows:

Femur 1 without a distal spine on the posterior side.

Metatarsi 1 and 2 with one distal ventral spine; without lateral spines near base.

Femur 3 without a median distal spine.

Patella 3 without a spine on the anterior side.

Metatarsus 4 without a median dorsal spine near base.

**Measurements:**

	Mm.	♀ Ratio
Length.....	10.00	217
Carapace:		
Length.....	4.60	100
Width.....	3.15	68
Tibia-patella:		
1.....	3.90	85
4.....	3.95	86

**Type locality:** About W. 111° 3' : N. 40° 45'. Utah: Chalk Creek, Uintah Mts., 10,000 ft. elev.; ♂ ♀ types; August, 1917; R. V. Chamberlin collector. (M. C. Z.)

**Known localities:** 107.38, ♀, Im., Colorado: Ouray; June 19, 1940; Wilton Ivie. 110.44, 3 ♀, Wyoming: Bridge Bay, Yellowstone Park; July 9, 1938; W. Ivie. 110.40, ♀, Utah: Mirror Lake, Uintah Mts.; August 18, 1942; W. Ivie. 111.45, ♀, Montana: Galatine Gateway; August 14, 1929; R. V. Chamberlin. 111.40, ♂ ♀, (Type locality). Types. 111.40, 3 ♀, Utah: upper Provo River; June 19, 1941; Wilton Ivie. 111.39, 2 ♀, Utah: Ferron Reservoir, Wasatch Plateau; June 24, 1934; Wilton Ivie and Herman A. Rasmussen. 112.37, 2 ♀, Utah: Cedar Mountain; August 1, 1935; A. M. Woodbury. 114.48, ♀, Montana: La Salle; August, 1934; Chas. Jellison, Jr. (Gertsch and Jellison, 1939.) 114.46, 2 ♀, Im., Montana: Moose Lake, Ravalli Co., May 6, 1934 (♀); Skalkaho Divide, July 15, 1934 (Im. ♀); Gird's Cr. Ravalli Co., August 26, 1934 (♀); W. L. Jellison. (Gertsch and Jellison, 1939.)

These spiders are typically found under the bark of dead pines and in crevices at high elevations.

**Amaurobius olympus** new species

Figures 15, 25, 37

*Color* typical. Dorsal pattern on abdomen obscure or only moderately developed.

*Structure*: Essentially typical. The male palpus has the mesal spur of the tibia unusually long and slender; the middle lobe is distinctly separated from the mesal spur. Female: Eye rows faintly procurved. A. m. eyes usually slightly larger than the p. m. eyes; about a radius apart, about 1.7 diameters from the side eyes. P. m. eyes about 1.6 diameters apart, about 3.0 diameters from the side eyes. Median ocular quadrangle about as wide behind as long. The principle spine modifications on the legs are these:

Femur 1 usually without a distal spine on posterior side.

Tibia 1 with 0 to 2 spines on anterior face.

Metatarsus 1 with two distal ventral spines, without lateral spines near base.

Femur 3 without a median distal spine.

Patella 3 without an anterior spine.

Metatarsus 4 usually without a dorsal median spine near base.

*Measurements:*

	♂ Holotype		♀ (Large)	
	Mm.	Ratio	Mm.	Ratio
Length....	8.60	200	12.00	210
Carapace:				
Length....	4.30	100	5.70	100
Width....	3.10	72	3.90	68
Tibia-patella:				
1.....	5.53	129	5.15	90
4.....	5.20	121	5.00	88

*Type locality*: Quadrangle W. 122° : N. 37°. California: King's Mt., near Palo Alto; ♂ holotype; Autumn, 1922; J. C. Chamberlin collector. (Univ. Utah.)

*Known localities*: (Types and paratypes). 118.34, ♀, California: "Los Angeles"; June. (Amer. Mus.) 121.41, 5 ♀, California: Bartle, July 21, 1941 (4 ♀); Dickson Flat, N. E. Shasta Co., July 21, 1941 (♀); W. M. Pearce. (Amer. Mus.) 121.37, ♀, California: Stevens Cr., Santa Clara Co.; April 20, 1941; W. M. Pearce (Amer. Mus.) 121.36, 2 ♀, California: Pacific Grove; March, 1913; R. V. Chamberlin. 122.47, ♂ ♀, Washington: Olympia. 122.41, ♀, California: Mt. Shasta City; August 25, 1931; W. Ivie. 122.37, ♂ ♀s, California: vicinity Palo Alto; 1921 to 1923; J. C. Chamberlin. Holotype, allotype, and paratypes. 122.37, 5 ♀, California: Ingleside. 122.37, ♀, California: Felton; March, 1913; R. V. Chamberlin. 123.42, 4 ♀, Oregon: Grants Pass; August 29, 1931, W. Ivie (3 ♀); September 9, 1935, Chamberlin and Ivie (♀).

**Amaurobius pallescens** (Chamberlin)

*Auximus pallescens* Chamberlin, 1920, *Pomona Coll. J. Ent. & Zool.*, 12:3, \*1: 3.

*Color* typical. Abdominal pattern indistinct.

*Structure* essentially typical. A. m. eyes larger than the p. m. eyes.

*Type locality:* About W.  $117^{\circ} 48'$  : N.  $34^{\circ} 3'$ . California: Claremont; immature ♀ holotype; Wm. A. Hilton collector. (M. C. Z.)

Since the type is an immature specimen, the correct placement of this species must await the examination of adult material from near the type locality.

### *Amaurobius pictus* Simon

Figures 12, 20

*Amaurobius pictus* Simon, 1884, *Proc. Soc. Zool. France*, 9: 320; \*3.

*A. pictus* Banks, 1900, *Proc. Wash. Acad. Sci.*, 2: 482.

*A. pictus* Banks, 1910, *Bull. U. S. Nat. Mus.*, No. 72: 19.

*A. pictus* Petrunkevitch, 1911, *Cat. Amer. Spid.*, 105.

*A. pictus* Emerton, 1919, *Trans. Royal Can. Inst.*, 12: 325.

*A. pictus* Chamberlin and Ivie, 1946, *Bull. Univ. Utah*, °°

*Color:* Essentially typical, but with the abdominal markings more extensive and showing greater contrast than in almost any other species. The sternum is dusky in the male, less so in the female. The legs usually show some faint annuli.

*Structure:* ♀. Both eye rows procurved. A. m. eyes slightly larger than the p. m. eyes, a little more than a radius apart, about 1.3 diameters from the side eyes. Median ocular quadrangle about as long as the posterior width. Chelicerae usually with three teeth on the hind margin of the fang groove, sometimes four. ♂. Similar to female, but with the typical modifications of the male, although these are less extreme than in certain other species. The tibia of the palpus has the median process very short, it being much shorter than the middle process. The spine modifications on the legs of the female are as follows:

Femur 1 with a posterior distal spine above.

Metatarsus 1 with one distal ventral spine, without lateral spines at base.

Femur 3 with a median distal spine above.

Patella 3 with an anterior spine.

Metatarsus 4 with or without a median dorsal spine near base.

#### *Measurements:*

	♂		♀	
	Mm.	Ratio	Mm.	Ratio
Length.....	8.60	200	9.20	200
Carapace:				
Length ...	4.30	100	4.60	100
Width.....	3.10	72	3.07	67
Tibia-patella:				
1.....	5.00	116	4.60	100
4.....	4.90	114	4.50	98

*Type locality:* "Washington State."

*Known localities:* 121.47, ♀, Washington: Snoqualmie Pass; Aug. 11, 1929; R. V. Chamberlin. 122.48, 2 ♀, Washington: Chchallis; Sept. 10, 1935; Chamberlin and Ivie. 122.47, 2 ♂ 2 ♀, Washington: Olympia. 122.47, 2 ♀, Washington: Tacoma; August 9, 1929; R. V. Chamberlin. 122.45, 2 ♀, Oregon: Portland. 122.45, ♀, Oregon: Perham Cr., Columbia Gorge; August 4, 1929; R. V. Chamberlin.

123.48, 2 ♀, British Columbia: Sidney, Vancouver Is.; Sept. 16, 1935; R. V. Chamberlin and W. Ivie. 123.45, Imm., Oregon: N. E. Mohler; August 25, 1936; Wilton Ivie. 123.44, ♀, Oregon: 8 mi. So. Salem; April 24, 1941; J. C. Chamberlin. 123.43, 2 ♀, Oregon: Comstock; Sept. 8, 1935; Chamberlin and Ivie. 124.49, ♂ 5 ♀, B. C.: Port Alberni, Sept. 12, 1935; Lake Cameron, Sept. 13, 1935; R. V. Chamberlin and W. Ivie. ♂, B. C.: Florence Lake; November 3, 1928. B. C.: Departure Bay, Vancouver Is.; J. H. Keen (Emerton, 1919.) 130.54, Alaska: Fox Point; July 26-27, 1899; Trevor Kincaid (Banks, 1900.) 134.58, 2 ♀, Alaska: Juneau; April 28-29, 1945; J. C. Chamberlin. 135.59, ♀, Imm., Alaska: Haines; August 20-25, 1945; J. C. Chamberlin. 151.60, Alaska: Cook Inlet; July, 1899; Trevor Kincaid (Banks, 1900.)

### *Amaurobius severinus* new species

#### Figure 26

#### Female.

*Color:* Carapace light brown, slightly darker on front of head. Chelicerae chestnut brown. Labium and endites reddish brown. Legs and palpi brownish yellow, with distal part of leg 1 and palpus darker. Abdomen gray; dorsal pattern obscure.

*Structure:* Very similar to *severus*, except for much smaller size. Anterior eye row about straight; a. m. eyes 0.4 diameter apart, 1.3 diameters from the side eyes. Posterior row procurved, p. m. eyes 1.7 diameters apart, 2.8 diameters from the side eyes. Anterior median eyes a little larger than the p. m. eyes. Epigynum similar to that of *severus*. Leg spination modified as follows:

Femur 1 with or without distal spine on posterior side.

Tibia 1 with 0 or 1 spine on anterior face.

Metatarsus 1 with two ventral spines at distal end, with or without lateral spines at base.

Patella 3 without spine on anterior side.

Femur 3 without median distal spine above.

#### Measurements:

	♀ 1	♀ 2	Average	Ratio
Length.....	10.00	10.00	10.00	217
Carapace:				
Length.....	4.80	4.40	4.60	100
Width.....	3.36	3.08	3.22	70
Tibia-patella:				
1.....	4.15	4.13	4.14	90
4.....	4.27	4.25	4.26	93

*Type locality:* W. 121° 5' : N. 35° 28'. California: Cambria, September 16, 1937; ♀ holotype, 2 immature paratypes (Amer. Mus.) ♀ paratype (Univ. Utah.)

### *Amaurobius severus* Simon

#### Figures 17, 27

*Amaurobius severus* Simon, 1884, *Bull. Soc. Zool. France*, 9: 319, \*2.

*A. severus* Petrunkevitch, 1911, *Cat. Spid. Amer.*, 105.

*A. severus* Emerton, 1919, *Trans. Royal Canadian Inst.*, 12: 325.



*Color:* Carapace brownish orange to reddish brown, more or less shaded or blackened on the front of the head. Chelicerae chestnut brown. Endites and labium dark brown in the female, brownish orange in the male; the endites with whitish tips. Sternum, legs, and palpi brownish orange; the distal segments of the male palpus more brownish. Abdomen dark gray to blackish, with a moderately developed pattern of light gray on the dorsum; lighter gray on the venter (in old females, the abdomen tends to become darker and the pattern obscured). Spinnerets orange brown. Epigynum reddish brown.

*Structure:* ♀. Size large. Head broad and robust. Both eye rows slightly procurved. A. m. eyes larger than p. m. eyes, less than a radius apart, 1.6 diameters from the side eyes. P. m. eyes 2.0 diameters or more apart, about 4.0 diameters or slightly less from the side eyes. Epigynum wide and transversely straight across the posterior edge. The more variable leg spines are as follows:

Femur 1 with a posterior distal spine.

Metatarsus 1 and 2 with two ventral spines at distal end, with one or two lateral spines near base.

Femur 3 usually with a median distal spine.

Patella 3 with or without an anterior spine.

Metatarsus 4 without a median dorsal spine near base.

♂. Typical, with the usual variations characteristic of the male, although these appear to be more extreme than usual. Palpus stout; the ectal spur of the tibia of medium length, only a little more than twice as long as the middle spur.

#### Measurements:

	♂		♀	
	Mm.	Ratio	Mm.	Ratio
Length	11 80	197	15 00	217
Carapace:				
Length	6 00	100	6 90	100
Width...	4 27	71	4 83	70
Tibia-patella:				
1	6 90	115	6 80	98
4	6 90	115	6 67	96

*Type locality:* "Washington State."

*Known localities:* 119.37, ♀, California: Aspen Valley, Yosemite Park; August 11, 1931; W. Ivie. 119.34, 3 ♀, California: Goleta; July 12, 1934; H. A. Rasmussen and W. Ivie. 121.36, ♀, California: Pacific Grove; Winter, 1932; Pearl Murray. 122.48, 4 ♂ 4 ♀, Washington: Chchallis; September 10, 1935; R. V. Chamberlin and Wilton Ivie. 122.47, ♀, Washington: Olympia. 122.38, 2 ♀, California: Marin County. 122.37, ♂ ♀, California: Atherton; December, 1927; J. C. Chamberlin. 122.37, ♂ ♀, California: San Francisco. 122.37, ♀, California: Berkeley. 123.49, 2 ♂ ♀, British Columbia: Nanaimo; Sept. 13, 1935; Chamberlin and Ivie. 123.48, ♂ ♀, B. C.: Sidney; Sept. 16, 1935; Chamberlin and Ivie. 123.48, ♂ 6 ♀, Washington: Sequim; J. M. Grant. 123.44, 2 ♀, Oregon: Corvallis. 124.49, ♂ 3 ♀, B. C.: Lake Cameron; Sept. 13, 1935; Chamberlin and Ivie. B. C.: Departure Bay, Vancouver Is. (Emerton, 1919.)

**Amaurobius shastus** new species

Female.

This species closely resembles *enus* in size, color, and structure, but can be separated from it on the basis of the leg spination in the female. In *shastus*, metatarsus 1 lacks the distal spines above, as well as the lateral spines near the base. It also has, occasionally or frequently, the following spines. A median distal spine on femur 4, an anterior spine on patella 3, a small dorsal median spine near base of metatarsus 4. The epigynum is similar to that of *enus*.

*Measurements:*

	Mm.	♀ Ratio
Length	10 00	204
Carapace:		
Length	4 90	100
Width	3 33	68
Tibia-patella:		
1	4 10	84
4	4 20	86

*Type locality:* W. 122° 25' : N. 41° 25'. California: Weed; September 8, 1935, ♀ holotype, 8 ♀ s paratypes; R. V. Chamberlin and Wilton Ivie collectors. Found in rotten logs.

**Amaurobius subnomeus** new species

Female

*Color:* Carapace yellowish to orange brown, dusky brown on the front and sides of the head. Chelicerae blackish brown. Labium and endites dark brown, with narrow whitish tips. Sternum yellowish, shaded with dusky, especially on the margins. Legs and palpi light brownish yellow. Abdomen gray, with the spots of the dorsal pattern largely coalesced, but distinct.

*Structure:* Close to *nomeus* and *pictus* in general appearance. It differs from *pictus* by lacking the spine on the anterior side of patella 3, and from *nomeus* by possessing a distal median spine on femur 3. The epigynum is very similar to that of *pictus* (see fig. 20).

*Measurements:*

	Mm.	♀ Ratio
Length	9 30	202
Carapace:		
Length	4 60	100
Width	3 30	72
Tibia-patella:		
1.	4 60	100
4	4 40	96

*Type locality:* W. 121° 55' : N. 36° 38'. California: Pacific Grove; ♀ holotype, ♀ paratype, August 18, 1932, S. D. Durrant; ♀ and immature paratypes, July 13, 1934, H. Rasmussen and W. Ivie; ♀ paratype, August 17, 1931, W. Ivie.

**Amaurobius tacoma** new species

Figure 32

Male.

**Color:** Carapace yellowish brown; sides of head reticulated with dusky. Chelicerae reddish brown. Endites orange. Sternum and labium dusky yellow. Legs light yellowish brown, with faint dusky annuli. Abdomen dark gray, with a distinct whitish pattern above, as in *pictus*.

**Structure:** Essentially typical. A. m. eyes slightly larger than the p. m. eyes, about 0.8 diameter apart, 1.2 diameters from the side eyes. Posterior row procurved; p. m. eyes about 1.6 diameters apart, 2.5 diameters from the side eyes. Palpus with mesal spur of the tibia slightly more than twice as long as the middle spur; it is bent mesad at about three-fifths of its length from the base, and is rather slender and uniform in thickness from base to near the tip.

**Measurements:**

	♂ Holotype	
	Mm.	Ratio
Length.....	8.00	187
Carapace:		
Length.....	4.27	100
Width.....	2.93	68
Tibia-patella:		
1.....	5.20	122
4.....	5.25	123

**Type locality:** W. 121° 44' : N. 46° 47'. Washington: Paradise Valley, Rainier Park; August 10-12, 1942; Borys Malkin. (American Museum.)

**Amaurobius tamarus** new species

Figures 6-10, 19

**Color** essentially typical, but tends to be lighter than usual. The sternum is not darkened. The labium and endites of the female are reddish brown. The abdominal pattern is typical, but sometimes lacks sharp contrast. The carapace of the male is unmarked.

**Structure** essentially typical. Eye rows about straight. A. m. eyes smaller than the p. m. eyes. Some of the more significant spine characters are as follows:

Male:

Metatarsi 1 and 2 with only one distal ventral spine.

Female:

Femur 1 with or without a distal spine on the posterior side.

Tibia 1 with one to three spines on the anterior face.

Metatarsus 1 with one ventral spine at distal end, without lateral spines near the base.

Femur 3 with a median distal spine above.

Patella 3 with a spine on the anterior side.

Metatarsus 4 with a small median dorsal spine near base.

Male palpus with the ectal process short, it being less than twice as long as the middle spur.

*Measurements:*

	♂ Holotype		♀ Allotype	
	<i>Mm.</i>	<i>Ratio</i>	<i>Mm.</i>	<i>Ratio</i>
Length.....	9.30	207	8.30	208
Carapace:				
Length.....	4.50	100	4.00	100
Width.....	3.20	71	2.70	68
Tibia-patella:				
1.....	5.60	124	3.60	90
4.....	5.20	115	3.65	91

*Type locality:* W. 116° 28' : N. 44° 57'. Idaho: Lost Valley Reservoir; August 20, 1936; ♂ holotype, ♀ allotype, ♂ ♀ paratypes; July 27, 1939, 8 ♀ paratypes; Wilton Ivie collector.

*Other locality:* 117.46, ♀, Washington: Wawawai.

DDT AND THE INSECT PROBLEM, by JAMES C. LEARY, WILLIAM I. FISHBEIN and LAWRENCE C. SALTER. VII. 176 pages. McGraw-Hill Book Company, Inc., 1946. Price \$2.50.

This timely little book is well printed, well illustrated and well written, and is attractively bound to boot. Although its avowed purpose is to present a summary for the user rather than a scientific treatment of the subject, it seems likely to provide valuable information even for entomologists unless they have been actively engaged in work with DDT. The reviewer is not among the latter, hence he has found it informative and entertaining as well.

The introductory chapter is a lucid summary of the proved values of DDT as an insecticide and the risks attending its extensive use where man and other animals are incidentally exposed to it. Even though the authors do not pretend to offer an exhaustive scientific survey, their treatment here seems reassuringly ample and judicious.

The chapter on Insects and Insecticides is brief and rather ordinary to an entomologist but should be informative to other readers.

Chapter III, on the Chemistry and Pharmacology of DDT, includes a discussion of the composition and manufacture of the substance and of its physiological effects. Even though brief it is an excellent and practical treatment of the action of the poison, the dangers attending its use, and methods of treatment in cases of poisoning.

The five remaining chapters cover methods of using DDT, its use in the war, its effectiveness in protecting man from the attacks of insects, and its use in agriculture and against forest, shade and fruit tree insects.

In spite of its small size the book is packed with information. It should be extremely valuable to anyone who has occasional use for insecticides and an excellent addition to the libraries of professional entomologists as well.—A. W. L.

# A LABORATORY METHOD OF REARING CHIGGERS AFFECTING MAN

(Acarina: Trombiculidae)

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## INTRODUCTION

The object of this research was to discover a method of rearing chiggers experimentally in the laboratory in order to provide colonies for the purpose of disease transmission studies of scrub typhus, and to provide chigger larvae for testing new acaricides and repellents under controlled laboratory conditions during the entire year. A second object was to obtain information about the little known but common pest species of chiggers affecting human beings in the United States.

Until the present study, chiggers had not been successfully reared through more than one generation, or reared through a single generation without very high mortalities. Numerous attempts have been made by workers to rear chiggers, but the exacting and different food or environmental requirements of each stage of the complex life history has prevented complete success in establishing a colony.

The first attempts to rear chiggers were made about 1917 by the Japanese in relation to the scrub typhus disease. The life cycle from larva to adult of the chigger *Trombicula akamushi* was described independently by Nagayo et al (1917), Miyajima and Okumura (1917), Kitashima and Miyajima (1918). They were able to feed the larvae on mice, and reared a few nymphs to adults by feeding pieces of melons, potatoes, and other vegetables. One adult contained eggs, but no second generation larvae were obtained from reared adults.

Ewing (1944) fed chigger larvae on turtles and toads, and reared nymphs of *Eutrombicula alfreddugesi* in the United States on feces of millipedes and springtails and obtained two adults. Blade et al (1945) working on scrub typhus in the New Guinea area, reviewed the literature in detail and state, "Attempts to carry mites through a complete cycle of development in the laboratory have not been successful. This has limited the scope of observations on experimental transmission of mite typhus." Melvin (1946), Michener (1946a) (1946b) and Jenkins (1946) working at Gorgas Memorial Laboratory, Panama City R. de P., reared *Eutrombicula batatas* (= *hominis*?) through its complete life history, but in no case was a method discovered of rearing enough chiggers to enable a colony to be maintained. Melvin used chicks as larval hosts and reared nymphs and adults in soil containing chicken feces. He mentions "mass culture methods" and "two or more" generations. Michener later made a very careful study and described the stages of the life history in detail. Using chicks as host animals and chicken feces as larval and adult food, he obtained about 10% adults from larvae, but

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had difficulty in getting the reared adults to lay eggs. Wharton and Carver (1946) and Wharton (1946), in detailed rearing experiments for the Navy on *Ascoschöngastia indica* in Guam, discovered that insect eggs are satisfactory food for the nymphs and adults, but reported difficulty in getting the larvae to engorge. Wharton (1946) in reviewing his own and all other published data (to July, 1946), stated, "No entirely satisfactory system for culturing trombiculid mites has yet been described."

Each of the investigators made valuable contributions to the knowledge of the species being studied and this information has been of advantage in starting the present colonies of the species of chiggers which affect man in the United States.

The common "chiggers" or "red bugs" which cause so much discomfort to human beings in many parts of the United States have been little investigated. The habits, hosts, life histories, distributions, and disease relationships have not been adequately studied. World War II aroused much interest in chiggers because of their importance as disease vectors of scrub typhus or "tsutsugamushi" which became a serious problem to the Armed Forces stationed in the Southwest Pacific where the disease is indigenous. Chiggers were also noxious pests during Army maneuvers in the southern part of the United States.

Three species of chiggers are known to affect human beings in the United States, and all of these species were successfully reared in the laboratory by the author. These mites are in the genus *Eutrombicula* which is nearly world wide in distribution. Two of the species, *Eutrombicula alfreddugesi* and *Eutrombicula masoni* are serious widespread pests of man, while the third, *Eutrombicula batatas* (= *hominis*?), is uncommon and restricted to only the southeastern part of the United States.

The life history of the chigger is comparatively complex and consists of seven stages which are: egg, deutovum, larva, nymphochrysalis (protonymph), nymph, imagochrysalis (preadult), and adult. The larvac, nymphs, and adults are the only active feeding and growing stages, while the others are resting or transition stages between the active forms.

#### PROCEDURE AND METHODS

The first rearing experiments were carried on in Panama from December, 1945, to March, 1946, and from then until March, 1947, in the United States in Florida, Texas, Maryland, and Ohio. The first rearing methods used in Panama were designed after Michener's (1946b), but eggs of the mosquito *Anopheles albimanus* were used as food for the nymphs and adults of *Eutrombicula batatas* and *Trombicula alleei*. These were reared through a complete generation but the mortality was still about 80% and second generation egg production was unsatisfactory. These methods were not suitable for rearing *Eutrombicula alfreddugesi* and *E. masoni* in the United States so that new methods and types of equipment were developed.

The rearing techniques, foods and equipment here described have been standardized as a result of continued testing. The factors which caused mortality and difficulties in rearing are included to prevent similar trouble to future workers. Methods and rearing containers were

continually modified during the research in order to (a) increase the per cent of survival in each stage, (b) reduce the length of time required for each generation, and (c) to reduce the time and individual handling required in rearing the colonies.

The laboratory colonies were started with larvae since they were the most abundant and easiest to obtain in the field. Adults, nymphs, and other stages were collected and reared, but they could not be obtained in sufficient quantities. Engorged larvae were obtained in large numbers by collecting the larvae from naturally infested vertebrate hosts, e g., 11,000 larvae from one black snake, and allowing the larvae to remain on the hosts until fully engorged. Unfed larvae were collected in the field by use of the black collecting boards shown in Plate IV, which were placed in areas with a high population of chiggers.

*Larval hosts and engorgement:* The chigger larvae would not develop further in their life history unless they attached and engorged on a vertebrate animal. A number of types of vertebrate animals were tested as hosts. In Panama, the author used small chicks with success as hosts in feeding larvae of *Eutrombicula batatas* and *Trombicula alleei*. Chicks were rather poor laboratory animals, however, because of the feeding and attention which they required. Their feces and spilled food trapped the engorged chigger larvae which detached and fell from the host into the rearing jar or tray of water beneath. Mice and other mammals presented the same laboratory disadvantages.

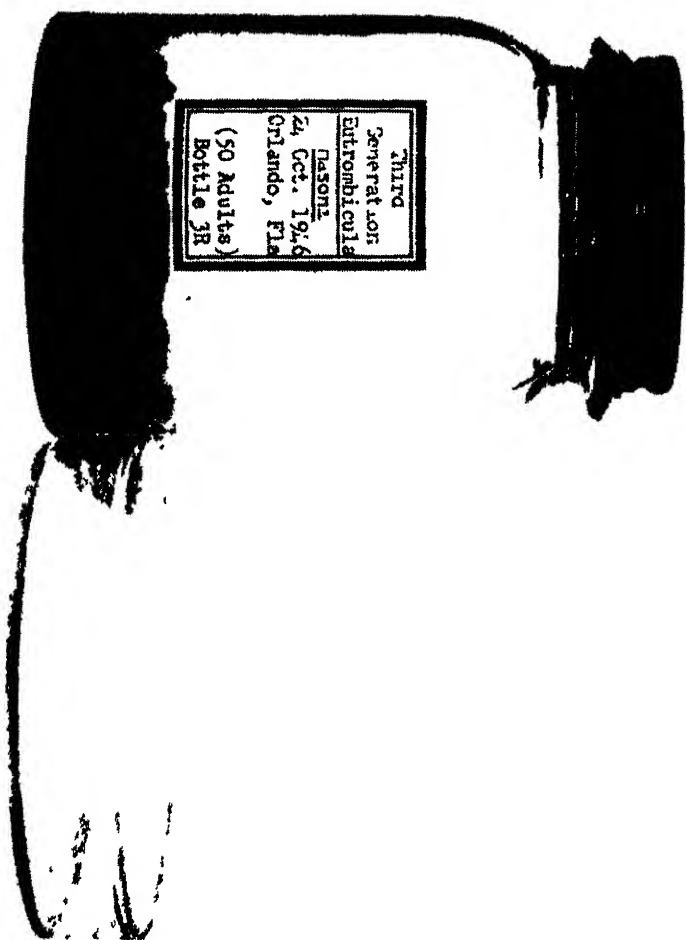
A number of species of snakes, lizards, and turtles were tested as hosts in Florida. It was found that unfed *Eutrombicula aldfredugesi* and *E. masoni* larvae would attach to these reptiles and engorge, producing healthy nymphs. Of the reptiles tested, the common box turtles *Terrapene carolina* (including the subspecies *carolina*, *bauri*, and *major*) proved to be the best host and laboratory animals. They are easily handled, require little care and survive well when fed only at intervals between experiments, so that there is little contamination by feces of the collecting funnel or rearing jar below. Another advantage of using turtles is that they molt only about once a year while snakes and lizards molt much more frequently and are more difficult to handle. Box turtles are important natural hosts and contribute much in causing high chigger populations in some areas. Snakes on the other hand sometimes have a higher number of attached larvae when collected in the field and the larvae are often larger and more fully engorged.

The turtles and snakes were placed in wire mesh cages and suspended above collecting funnels which were suspended over the rearing jars as shown in Plate I. When the larvae were fully engorged, they detached from the host and dropped into the collecting funnel and were concentrated into the moist soil in the bottom of the rearing jar. The circular cage was made of one-half inch mesh rabbit screen and could be opened at the top. The collecting funnel was made of celluloid. A thin layer of vaseline was spread around the inner lip of the top and the outer lip of the bottom of the funnel to prevent larval escapes. The cage and funnel were suspended separately so that the funnel did not touch either the cage or rearing jar. This method collected 100% of the larvae into the rearing jar with no individual handling as was required when using cages with a tray of water beneath as described by Michener (1946b).



Cage containing a black snake host suspended over a collecting funnel and rearing jar. After engorgement, the chigger larvae detach from the host and fall into the rearing jar.





Rearing jar used for all stages of the life history except feeding the larvae. The jar is kept in the petri dish



Turtle host suspended over rearing jar to transfer reared larvae to host for obtaining new generations. Note vaseline ring at top of bell jar to prevent chigger escapes.

Black cardboard used to attract and collect unengorged larvae in the field for testing miticides and making identifications.



Engorgement of the larvae on the box turtle in central Florida required an average of about eight days, early and late in the season, but in the warmest period during July and August, only three or four days were required for engorgement of the majority of the larvae.

Turtles and snakes were collected in the field and daily counts were made of the engorged larvae which dropped off. When all larvae had detached, the chigger free turtles were staked out for periods of one to five hours in areas with high chigger populations. About 500 larvae was considered to be a good infestation. The larvae did not appear to cause any discomfort or damage to the turtles or snakes, and no swelling or abscesses occurred as in birds and mammals.

*Rearing container:* The container for rearing chiggers must meet several exacting requirements in the different stages of the life history. An air temperature between 25° and 35° C. and a relative humidity of about 85% to 100% should be maintained without any droplets of water being formed on the inside of the container. The medium or substrate must be nearly saturated, but should allow free movement of the animals in the interstices, and should not have any poisonous properties. Sufficient ventilation is needed even though the container must be sealed tight enough to prevent escape of the minute unfed larvae.

The rearing jar shown in Plate II, has been perfected to take care of all stages of the life history except during the engorgement of the larvae on the vertebrate host. After many failures, the jar finally adopted was made in the following way. The bottom inch was cut off of a pint glass screw top jar. The two and one-half inch metal lid had a half-inch hole drilled in the center and was plugged with cotton to provide ventilation and to help prevent steaming or water condensation inside the jar. The open bottom of the jar was plugged with a three-eighths inch layer of plaster of Paris containing about 10% activated charcoal. After drying, the plaster of Paris was covered with a thin layer of activated charcoal to absorb all odors and to cover any poisonous elements of the plaster. A layer of sterilized humus or moist sandy soil about one-fourth inch in depth was placed in the jar. The sandy soil contained some humus after screening. It was found that coarse sand particles prevented packing of the soil and allowed freer movement of the chiggers. The soil was collected from areas in the field having a high chigger population, and was sterilized for one hour in an autoclave at 20 lbs. pressure to prevent possible contamination of the cultures.

In earlier experiments, engorged larvae were placed in a half-pint clamp top mason jar coated on the inside with a thin layer of plaster of Paris as described by Michener (1946b). The engorged larvae and the following stages, the nymphochrysalis and nymph require nearly 100% humidity. At this humidity, condensation of water droplets occurs in the bottle on the glass, and the engorged larvae are entrapped and die. A thin layer of plaster of Paris lining in the bottle allows a 100% humidity without any moisture droplets. This worked quite well with *Eutrombicula batatas* and *Trombicula alleei* in Panama, but heavy mortalities resulted when rearing the United States species. Addition of activated charcoal to the plaster of Paris resulted in less mortality and healthier nymphs. Use of this plaster of Paris lined bottle necessitated extra handling and involved transfer of the nymphs to the rearing jar

containing soil. This handling resulted in about a 10% loss and injury to specimens so that a new method was developed.

In the method finally adopted, the engorged larvae dropped directly from the vertebrate host animal into the rearing jar containing soil, and the nymphs and adults were reared with no additional handling. A narrow ring of vaseline was coated inside the jar about one-half inch above the soil to prevent larvae from crawling up the glass. The soil in the jar was moistened daily by adding water from a medicine dropper, and the excess drained out through the plaster of Paris bottom into a petri dish in which the bottle was placed. After an average of two days, the larvae turned into the nymphochrysalis resting stage, and nymphs hatched in about one week.

The rearing bottles were kept at a temperature of 28° to 32° C., but extremes in temperature of 24° and 36° C. were observed at times. In September, the colony was placed in a temperature chamber and the temperature was maintained between 28° and 30° C. The relative humidity of the rearing jars ranged from 86% to 100% using wet-dry bulb thermometers for measuring the humidity.

*Nymph and adult rearing:* The habitat and food requirements of the nymphs and adults are similar, and the rearing jar described above is suitable for their culture. The nearly saturated sterilized sandy soil provided a satisfactory substrate or medium. No individual handling or care was necessary other than daily moistening and feeding at weekly intervals. The temperature and relative humidity was maintained the same as for previous stages.

The best food for the nymphs and adults was found to be insect eggs as reported by Wharton and Carver (1946). Feces from chickens and other animals, and vegetable material was not considered to be suitable food. In Panama, the present author fed the eggs of the malaria mosquito *Anopheles albimanus* to the nymphs and adults with fairly good results. In the United States, the eggs of the yellow fever mosquito *Aedes aegypti* were fed with excellent success. Eggs of other insects such as the housefly and *Drosophila* were also tried, but they hatched after a few hours and could not be stored. *Aedes aegypti* eggs remained in good condition for a long period, and were ready for use at any time. At first only eggs laboriously excised from the gravid ovipositing female mosquitoes were fed to the young nymphs since they had difficulty in piercing the mature egg shells. It was discovered that moistening the mature eggs slightly, permitted the young nymphs to pierce the egg shell and allowed feeding. If the eggs were moistened too much, the mosquito larvae hatched, rotted, and ruined the culture.

If sufficient food was not provided, the nymphs and adults became cannibalistic and ate each other and probably ate some of the other stages. The growth of the nymphs was rapid, and full size was attained in two or three days if an abundant supply of food was available. Besides moistening the mosquito eggs, it was necessary to maintain an optimum soil moisture and humidity which provided sufficient moisture to prevent drying of the nymphs and adults. An excess of water caused the nymphs to become stuck to the soil or jar and caused death. The nymphs transformed into the imagochrysalis stage in about ten days

and remained inactive for four to nine days before they emerged as mature adults.

To determine the amount of food eaten by adult chiggers, a series of ten adults two days old were starved for 24 hours and then fed *Aedes aegypti* eggs. The adults ate an average of 15 eggs in one and one-half hours taking from 6 to 10 minutes to suck out the contents of a single egg. The mosquito egg was grasped by the long fore legs of the mite, pulled crosswise, firmly grasped by the cant-hook like claws of the pedipalps and held firmly in place from the rear by the second pair of legs. The sharp pointed chelicerae were then pushed into the egg, being inserted approximately half their length. The egg was usually pierced at about the middle, and when sucked out was often pierced at either end to completely empty the egg. From a side view using transmitted light, the contents of the egg may be observed passing into the adult as it greatly contracts and expands its abdomen and cephalothorax while sucking.

The optimum number of adults per rearing jar was found to be about 30 to 50, but larger numbers may be used. Individual jars have been maintained for six months without excessive losses of adults when properly cared for.

*Egg laying:* The problem of obtaining egg production was quite difficult at first and only a few eggs were observed when rearing *E. batatas* and *T. alleei* in Panama. Following the results of Melvin (1946), some cultures were placed in a temperature chamber at 35° C. for nearly two days, but this resulted in 100% mortality of the adults and no egg laying.

In the United States, experiments were carried on in which the temperature, relative humidity, and light were varied, and it was found that a temperature range from 27° to 34°, averaging 30° C., produced the best egg laying results. Exposure to 0° C. for several days did not stop egg laying, but at temperatures above 35° C. the production was greatly reduced. The humidity was kept above 85% and the substrate was quite moist. Variation of light in the present experiments did not produce noticeable effects in egg production.

Little has been known about egg production in chiggers, and most of the reports have been contradictory. In the present colonies, egg laying has been observed for a period of one year for *E. masoni*, and ten months for *E. alfreddugesi*.

The eggs were laid singly on the surface or in the interstices of the soil. The average number of eggs laid per day in the month of September was about 10 per female. The maximum observed was 20 eggs per female per day. Previous reports that females contained a maximum of only one egg when mounted on a slide were probably due to the destruction of the immature eggs by clearing agents. Individual females have laid eggs for periods of over six months. A very definite ovulation cycle has been observed in the egg and larval production by reared adults. Adult females only seven days of age have produced eggs which developed into larvae thirteen days later.

*Transfer of second generation larvae to host:* The newly hatched second, or later generations of unfed larvae were transferred to the

turtle host by suspending the turtle over the opened rearing jar as shown in Plate III. This method takes advantage of the positive phototaxis geotropism of the larvae and their increased activity at higher temperatures. The larvae crawled rapidly up the rearing jar onto the turtle (or caged snake) and attached after several minutes. Shaking or blowing in the jar, and varying the light intensity stimulated larval activity. This method has worked well when the rearing jar was braced in the center of an open bell jar which had a vaseline ring on the inner lip to prevent any chiggers from escaping. On some turtles, nearly 100% of the larvae attached and engorged. This arrangement was found to be superior to placing the rearing jar on a metal saddle above the turtle, since the larvae would not migrate down the outside of the rearing jar onto the turtle.

When transferring small numbers of larvae, or when making accurate counts of the emergences, a hand method worked quite well. The larvae were picked from the rearing jar by means of a moistened strip of paper held in forceps. The larvae were transferred to a droplet of water on the back of the host turtle or snake so as to wash off the larvae from the paper onto the host animal. To prevent escapes, the opened rearing jar was placed inside a ring of water or vaseline on a dark surface and stray larvae were recaptured.

Individual turtles were found to vary greatly in their attractiveness or susceptibility to chigger attachments. A few turtles were always 100% susceptible to the chiggers, while other turtles showed a variation of susceptibility at different times, especially in the evening when attachments were at a minimum. This problem deserves further study. Snakes were found to be more attractive hosts to the chigger larvae.

After the larvae had been transferred to the hosts, the turtles or snakes were replaced in the cages and the engorged larvae were collected in the rearing jars beneath the collecting funnels as before and the whole rearing procedure repeated.

#### DISCUSSION

Using the laboratory methods and materials described above, four generations have been reared of the chiggers which affect human beings in the United States: *Eutrombicula alfreddugesi*, and *E. masoni*. *E. batatas* (= *hominis*?) has been reared into the second generation. The methods have been duplicated several times using chiggers from different sources, and adults have been reared under natural and controlled temperature conditions. Sufficient numbers of reared larvae have been produced to permit experimental studies and limited acaricide tests to be carried on. The reproductive potential of chiggers is quite high; one culture of 23 females produced over 6,000 second generation larvae in two months.

Approximately 3,500 first generation adults and 2,500 second generation adults have been reared through their complete life histories with an efficiency of about 70%, (excluding those lost during experimentation).

Further details of the exact daily emergences and the numbers of each stage will be presented in a separate report along with the results

of studies on certain phases of the ecology, distribution, taxonomy and physiology of these species of chiggers.

The minimum time required to develop through a single generation and through each stage in the present cultures is summarized in the following table. The time required for second and later generations is approximately the same as for the first generation.

TABLE I  
LENGTH OF TIME REQUIRED FOR CHIGGER DEVELOPMENT  
(Minimum time)

STAGE	<i>E. masoni</i>	<i>E. alfreddugesi</i>	<i>E. batatas</i>
	<i>Days</i>	<i>Days</i>	<i>Days</i>
Egg.....	6	6	5
Deutovum.....	7	7	7
Larva (unfed).....	1	1	1
feeding on host).....	3	3	4
(fed).....	2	2	2
Nymphochrysalis.....	6	6	6
Nymph.....	9	11	15
Imagochrysalis.....	6	7	6
Adult.....	10	12	25
Total.....	50	55	71

This laboratory method of rearing chiggers can be recommended with a minor reservation. It has been tested throughout a whole year and on the three species of chiggers affecting human beings in the United States. A disadvantage of this method is that rather large quantities of mosquito eggs are required, and no easily obtained substitute food has been discovered in the present project to date.

#### ACKNOWLEDGMENTS

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THE NORTH AMERICAN CLEAR-WING MOTHS OF THE FAMILY AGERIIDAE, by GEORGE P. ENGELHARDT. United States National Museum. Bulletin 190, 222 pages, 32 plates (16 colored), 1946. Price 75 cents.

Beutenmuller's beautifully illustrated monograph of this family was for many years the only comprehensive treatment available. Since it is now forty-six years old the study of these interesting moths has necessitated reference to scattered literature and the publication of Engelhardt's revision will be a valuable aid to lepidopterists. It is unfortunate that the author could not have lived to witness the consummation of his lifelong study of the group.

According to the foreword by Carl Heinrich the author had worked over the group with the late August Busck, who took over the preparation of the manuscript and completed it before his own death in 1944. This collaboration of a leading specialist on the family with a great authority on the taxonomy of the microlepidoptera is ample testimony to the soundness of the resulting classification. The inclusion of seven new genera, nineteen new species and twenty new subspecific names suggests that the family will not soon be subject to further changes.

The monograph is in the form that satisfies a taxonomist, with an ample introductory discussion of the characteristics of the family, keys to genera and species, ample descriptions and notes on distribution, data on the location of types and notes on habits and life history if available. The black and white plates include figures of wing venation and genitalia and the colored plates include one hundred figures of adults. While the colored figures are not of the highest quality they are very good and should be satisfactory for identification.—A. W. L.

# A STUDY OF THE MIGRATORY HABITS OF SALT MARSH AND ANOPHELINE MOSQUITOES<sup>1</sup>

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In the initial field use of the Insecticidal Aerosol Generator (1946) developed at Columbia University it was found necessary, for the proper evaluation of the extent of more or less immediate mosquito adult kill obtained by the DDT aerosol projected from the generator, to study the migratory habits of the natural mosquito population in the particular test area chosen.

The daily migratory habits of the salt marsh species, *Aedes sollicitans* and *Aedes taeniorhynchus*, were determined by making landing rate measurements, the number of mosquitoes landing per minute, in various locations in and about an open marsh land at Sykes Creek, near Cocoa, Florida, at various times of the day over a 24-hour period. The counts were made over complete body of personnel after remaining stationary for one minute. The following typical locations were chosen:

- (a) Laurel tree (good canopy) on a road leading to the creek.
- (b) Palm tree (fair canopy) on the same road.
- (c) Middle of bridge crossing the creek (exemplifying completely open conditions).
- (d) Laurel tree (good canopy), on the marsh land, located near edge of creek but dry under the tree.
- (e) Open pickle weed grounds on the marsh land.
- (f) Mangrove tree (fair canopy), on the marsh land, water under it.

The results are tabulated in Table I and the landing rate measurements obtained under the canopy of the laurel tree at the creek's edge and on the open pickle weed marsh are graphically represented in figure 1.

These counts made over a 24-hour period show:

(a) At about dawn, migration starts from open areas into shaded areas in or about the open marshes. This migration occurs over a period of at least one hour and the minimum count in the open marshes is obtained at about 8:00 A. M. and then shows a measureable increase in the hot sun of the late afternoon.

(b) At about dusk, full migration starts from shaded areas into the open marshes.

(c) Dawn flights decrease the mosquito population in the open marshes but do not reduce the counts to zero. Fairly high counts are obtainable in the open marshes even under bright sunlight.

<sup>1</sup>This paper is based on work done for the Office of Scientific Research and Development under O.S.R.D. contract OEMsr 1388 with Columbia University, Prof. Victor K. LaMer, Contract Director.

TABLE I

LANDING RATE MEASUREMENTS (NUMBER OF MOSQUITOES LANDING PER MINUTE)  
AS A FUNCTION OF TIME. SALT MARSH MOSQUITOES; COUNT MADE  
OVER FRONT AND BACK OF PERSONNEL

Location	Laurel on Road	Palm on Road	Bridge	Laurel, Creek Edge		Pickleweed	Mangrove
				Outside Canopy	Under Canopy		
7-13-44 7:30 P. M.	100†	50†					
8:00	15	10	1	17	43 35	10 8	2
8:15	45	10	0		20 15		
8:30 Sundown 8:35	45	10	0	9	16	10 18 10	
8:40							27 12†
8:45 Dusk				23	20	30†	
8:50	85††	25	0			40†	70† 70†
8:55						60†††*	
9:00 Twilight				45†††	19	40†††*	80† 50†
9:10	100†	20	0	80†††	8	60†††*	
9:15							100† 70††
9:30 Dark	80	7		50	15		35†† 25††
9:36 P. M.							57†† 35††
7-14-44 5:15 A. M., Dark	60†††	20	18				
5:25					28 18	48 63	55†† 75††
5:35, Crack of Dawn	75†††	25	45		35 32	48 53	60†† 75††
6:00, Dawn	70†††	50	30		19 25	100† 100†	120†† 120††
6:07							150†† 150††
6:15	60†	100	10				
6:30, Sunrise behind Clouds	100†††	150†	5		100†† 100††	90 85	165†† 170††
6:45	200††	100	0		200†††200†††	78 62	255†† 225††
7:00, Sun 5-10° above Horizon	200††	150	0				200†† 190††
7:06					200†††200†††	33 28	
7:15	200††	150	0				170†† 180††
7:30	200††	150	0	200†††	200†††	21 22	110†††100†††
7:45	200††	150	0	200†††	200†††	10† 9†	60†††100†††
10:30, Bright Sun	250†	150	0	200†††	200†††	17 19	125† 120†
4:45 P. M.	250†	40	0				
5:00 P. M.	125	30	2		200† 200†	44 50	125† 150†

Wind Speed:

7:30 P. M. period—2-4 mi. per hr.

5:15 A. M. period—1½ mi. per hour.

\*These counts included only the shirt. Count more likely in neighborhood of 100.  
†Indicates many also flying about.

(d) Greatly increased activity of mosquitoes in the open marshes was noticed before dawn and just after dusk. This was evidenced by loud humming and by large numbers of mosquitoes in the flashlight beam. This is further evidence of dawn and dusk migration.

(e) No definite data is obtainable on the long range migrations into nearby towns and other populated areas. Probably some of the

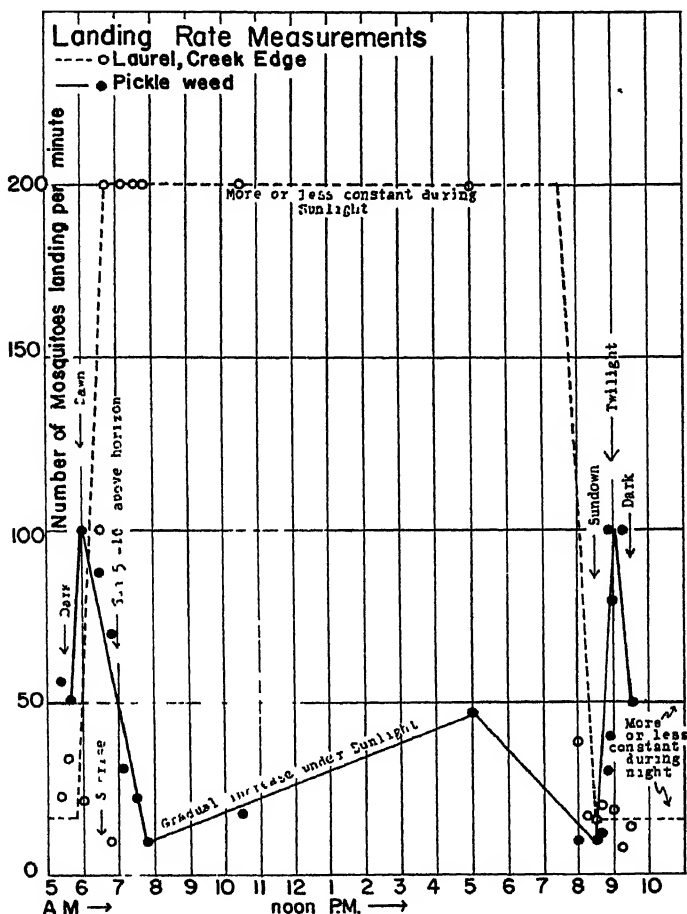


Figure 1

mosquitoes migrating out of the open marsh in the early morning continue to fly toward the towns during favorable hours and do not return until ready to lay eggs.

Hence it may be concluded:

(1) That a complete reduction of the landing rate to zero when obtained in an open marsh after treatment by a DDT aerosol over the dawn period may be attributed to the effectiveness of the aerosol. A

certain fraction of the reduction may also be attributed to the migratory habits of salt marsh mosquitoes.

(2) That a mangrove tree count of zero at 8:30 A. M. obtained after a dawn treatment represents kill and not migration.

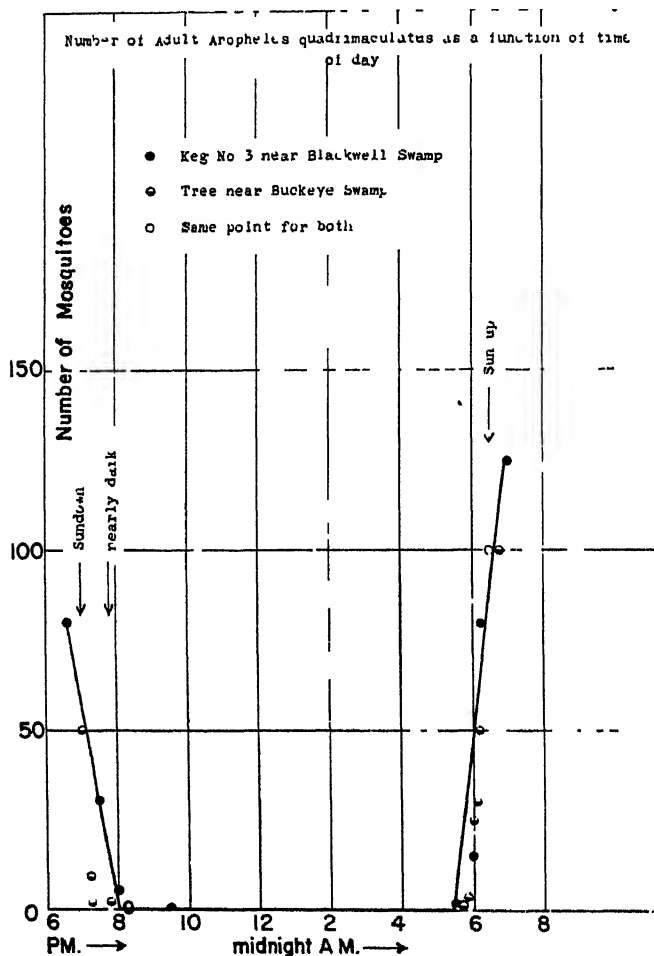


Figure 2

(3) That for practical control, the open marshes should be treated in the "predawn" period and the woods or forested areas after dawn as long as good meteorological conditions can be obtained.

It should be emphasized that although the population is comparatively low in the open marshes under sunlight, it is not zero. The tabulated results show that fairly high counts are obtainable in the open

marshes even under bright sunlight. In addition, when on several occasions the open marsh area was being inspected under bright sunlight for larvac pools, mosquito biting rates were annoyingly positive.

On the other hand, a study of the migratory habits of the *Anopheles quadrimaculatus* in several test areas of Buckeye and Blackwell Swamps (near Decatur, Ala.), showed that this species is completely inactive during periods of sunlight. While standing very close to a barrel or a tree hole containing such adults under conditions of sunlight, they have no tendency to land or bite. If a barrel is shaken, the adults leave the barrel and about 25% of them return within a half-hour. The results of the migratory habits are recorded in Tables II and III and two

TABLE II  
BLACKWELL SWAMP (DECATUR, ALABAMA). NUMBER OF ANOPHELINE  
ADULTS IN RESTING PLACES

Time	Number of Adults in Kegs			Number of Adults in a Tree Hole	Remarks
	#1	#2	#3		
August 18: 6:35 P. M.	200	500	80	30-50	
6:50				37	Sundown.
7:30		200	30	17	
7:45				13	Nearly dark
8:00	4	19	5		
8:15		21	0	3	
9:30	4	18	1		
August 18-19: 9:30 P. M.- 5:30 A. M.	4	18-16	1-4		Becoming light at 5:30 A. M.
6:00	81	32	15	6	
6:15		150	80	26	Fully light
6:30	125	200	100	29	Sun up
7:00		275	125		

typical cases are graphically represented in fig. 2. Between sunrise and dark, this species rests in some dark, cool, damp place such as a tree hole, hollow log, or empty keg. During the hour or so following sunset, they leave their resting places.

The results show it is possible to effect control of the adult by aerosol treatment (1946)

- (1) during the day while they are resting in their tree holes,
- (2) at dusk over the time they are leaving their tree holes,
- (3) in the early morning over the time they are returning to their tree holes.

As previously mentioned, the anopheline adult is completely inactive during resting periods. The data in Table III show that the adults

TABLE III  
BUCKEYE SWAMP (DECATUR, ALABAMA). NUMBER OF ANOPHELINE  
ADULTS IN RESTING PLACES

Time	Number of Adults in Kegs		Number of Adults Landing on Observer near Kegs	Number of Adults in a Tree Hole	NUMBER OF ADULTS	
					In Flight about Observer near Tree Hole	Landing on Observer near Tree Hole
August 18: 7:00 P. M.	#1 6	#2 25	0	50	2	1
7:10				9	1	2
7:15	3	6		1	0	2
7:30	3		2			
7:45	1	1		0	1	1
8:10 P. M.	0	0	0	0	0	0
August 19: 5:30 A. M.	0	0	0	0	3	1
5:50	0	0	0	3	10	2
6:00	0	0	1	25	20	5
6:07				30	20	4
6:10	0	0	2	50	15	3
6:18	1	5	2		5	2
6:30	5	8		100	1	1
6:40 A. M.	4	10	0	100	0	1

while in flight also have little tendency to bite observers located close to their resting places. The reluctance of these adults to bite in the vicinity of their resting places while in flight is substantiated by landing rate measurements made in the woods at a distance of 50 to 200 feet from the holes. At such points, the landing rate was practically zero for all times over the 24-hour period. From this data, it may be concluded that the anopheline adults inhabiting the woods about Buckeye and Blackwell swamps have, on the whole, acquired definite preferences, probably from habit, for specific locales in which blood meals are daily sought.

Although it is well known that mass migration of salt marsh species out of jungle areas occurs at dusk, nevertheless landing rates of over 100 have been obtained during the night in such areas.

The assistance of Lt. Comdr. George E. Bohart of Navy Medical Research Unit No. 2 and Dr. L. D. Anderson of the Department of Agriculture is gratefully acknowledged.

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## IXODES BISHOPPI, A NEW SPECIES FROM GEORGIA (ACARINA: IXODIDAE)

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In the course of routine examinations of birds and mammals captured at Savannah, Ga., the authors collected numerous specimens of a new species of tick, *Ixodes bishoppi*. The species is related to *I. minor* Neum. and *I. muris* Bishopp and Smith, and has similar host relationships. The larvae and nymphs were fairly common on cotton rats, *Sigmodon hispidus hispidus* Say and Ord., and were occasionally found on birds. Of 56 cotton rats examined 40 were infested, carrying a total of 191 larvae and 40 nymphs. Of numerous birds of various species examined 3 were infested; a house wren, *Troglodytes aëdon aëdon* (Vieill.), with 5 larvae and 1 nymph, a house wren with 8 larvae, and a towhee, *Pipilo erythrophthalmus erythrophthalmus* (Linn.), with 6 larvae and 2 nymphs. One of several house mice, *Mus musculus musculus* Linn., caught in a grassy field was infested with 2 larvae. Of 13 cotton-tail rabbits, *Sylvilagus floridanus* ssp., only 1 was infested, carrying a single nymph. Adult ticks were collected only twice, in each instance from a cotton rat. One rat was infested with 1 male and 7 females, the other with a single female. Numerous males and females, including the types, were reared from specimens collected as larvae or nymphs.

### *Ixodes bishoppi* n. sp.

*Female* (Plate I, A, B, and C).—Capitulum, length 771  $\mu$  (from tip of hypostome to line drawn between tips of posterior lateral angles of basis capituli); basis capituli, width 393  $\mu$ , reddish brown, posterior margin slightly concave, posterior lateral angles prominent and rounded, porose areas shallow, almost reaching posterior margin of basis capituli, roughly ovoid, their width (87  $\mu$ ) about equal to the interval between them; ventrally with long, pointed auriculac that project ventrally and posteriorly from the basis capituli and curve slightly mediad. Palpi long and slender (length 626  $\mu$ ), article II distinctly longer (320  $\mu$ ) than article III (233  $\mu$ ), article I with a long, sharp spine ventrally. Hypostome long, slender, sides tapering from the apical fourth to a sharply rounded tip; 4 rows of teeth on each side near the tip, followed by 3 rows near the center and 2 rows near the base; about 5 teeth in inner row, 7 teeth in next row, and 10 in each of the 2 outer rows, with additional small teeth at the apex not aligned with any row.

Scutum, length 1,260  $\mu$ , width 840  $\mu$ , broadest at the middle, tapering behind the middle, posterior margin rounded; reddish brown, coarsely punctate, punctations most numerous on posterior third, a few short pale hairs; cervical angles moderately long, broadly pointed; cervical grooves shallow, widely divergent posteriorly, reaching almost to the margin of the scutum near the posterior third; lateral carinae short, faint.



Legs brown, slender, all tarsi abruptly tapered near the tip, this especially pronounced in tarsus I; tarsus I almost twice ( $480\ \mu$ ) as long as metatarsus I ( $262\ \mu$ ). Coxae separated by a narrow interval (in unfed specimen); coxa I with a long, sharply pointed, internal spur; a short external spur on all coxae, longest on coxa II.

Stigmal plates of moderate size ( $233 \times 204\ \mu$ ), broadly oval, the long axis transverse to the body axis; macula nearly circular, located near anterior margin.

Body light brown, a few punctations and short pale hairs, the hairs longer and more numerous on the marginal fold; marginal groove deep, extending from shield around posterior margin; genital grooves divergent, reaching posterior margin of body; vulva between coxae IV; anal groove rounded in front, converging behind anus, reaching posterior margin of body.

Eleven other females, reared from nymphs or larvae from various lots, showed the following variations in dimensions (maximum, minimum, and average respectively): length of capitulum— $870\ \mu$ ,  $780\ \mu$ ,  $828\ \mu$ ; width of basis capituli— $480\ \mu$ ,  $390\ \mu$ ,  $429\ \mu$ ; length of palp— $720\ \mu$ ,  $630\ \mu$ ,  $660\ \mu$ ; length of palpal article II— $390\ \mu$ ,  $330\ \mu$ ,  $354\ \mu$ ; length of palpal article III— $240\ \mu$ ,  $210\ \mu$ ,  $228\ \mu$ ; length of scutum— $1,440\ \mu$ ,  $1,320\ \mu$ ,  $1,392\ \mu$ ; width of scutum— $990\ \mu$ ,  $900\ \mu$ ,  $909\ \mu$ ; length of tarsus I— $540\ \mu$ ,  $480\ \mu$ ,  $534\ \mu$ ; length of metatarsus I— $300\ \mu$ ,  $240\ \mu$ ,  $249\ \mu$ . In some females the porose areas are circular and in some, tarsus I is more than twice as long as metatarsus I.

*Male* (Plate II, A, B, and C).—Capitulum, length  $466\ \mu$ ; basis capituli dark reddish brown, width  $276\ \mu$ , widest behind base of palpi, narrowed posteriorly, posterior margin faintly convex, posterior lateral angles long and pointed; ventrally with sharp, triangular auricularae, posterior margin convex. Hypostome notched at the tip, armed on each side with a row of serrate plates and one row of teeth. Palpi short,  $320\ \mu$  long, article II,  $160\ \mu$  long, article III,  $116\ \mu$  long, article I protruding ventrally as a short, broad, 3-sided tooth.

Scutum reddish brown, length  $1,339\ \mu$ , width  $698\ \mu$ , pseudoscutum distinguishable, darker and more convex than rest of scutum, coarsely and closely punctate, punctations most numerous near the center, a few short hairs; cervical grooves distinct, converging then diverging, not reaching the margin of scutum; cervical angles rounded.

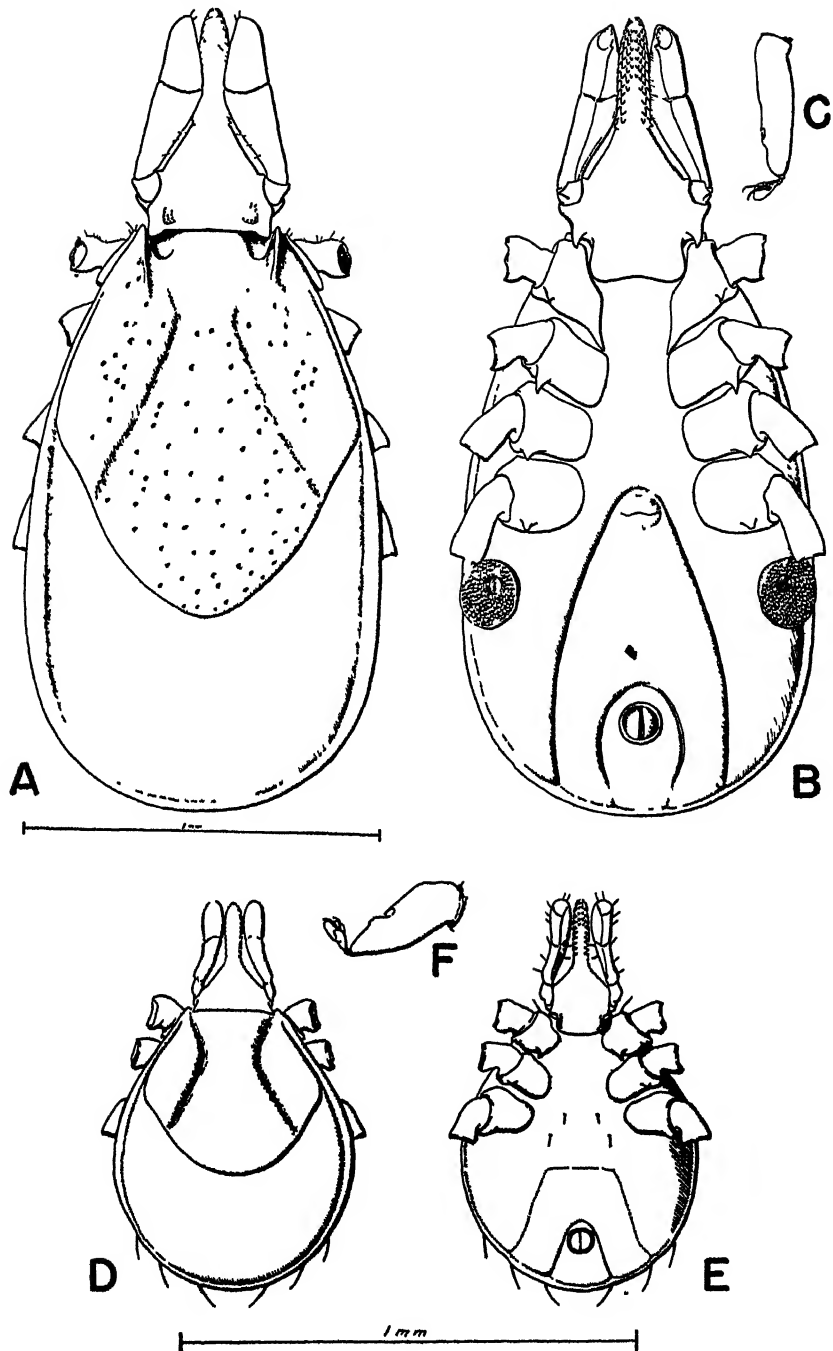
Legs light brown, tarsi abruptly tapering as in the female, tarsus I,  $364\ \mu$  long, metatarsus I,  $160\ \mu$  long; coxae not contiguous, coxa I with a short slender internal spur, all coxae with short, broad, external spurs, shortest on coxa I.

Stigmal plates of moderate size,  $218 \times 160\ \mu$ , oval, the long axis parallel to the body axis; macula circular, located near ventral margin.

Body, marginal fold wide, light brown, with a few pale hairs; marginal groove deep, reaching the margin at the anterior sixth; venter

#### EXPLANATION OF PLATE I

*Ixodes bishoppi* n. sp. A, Dorsal view of female. B, Ventral view of female. C, Lateral view of tarsus I of female. D, Dorsal view of larva. E, Ventral view of larva. F, Lateral view of tarsus I of larva. Drawn by Arthur Cushman,



brown, with scattered punctations and pale hairs. Pregenital plate  $218\ \mu$  long,  $131\ \mu$  wide, tapering anteriorly; median plate  $553\ \mu$  long,  $407\ \mu$  wide at widest part, anterior margin gently concave, sides gradually diverging to posterior sixth then sharply converging, posterior margin rounded; adanal plate  $320\ \mu$  long,  $204\ \mu$  wide at anterior end, tapering to posterior margin; anal plate  $306\ \mu$  long,  $218\ \mu$  wide, anterior margin narrowly rounded, posterior margin broadly rounded, anal groove as in the female.

Ten other males, reared from nymphs or larvae from various lots, showed the following variations in dimensions (maximum, minimum, and average respectively): length of capitulum— $495\ \mu$ ,  $436\ \mu$ ,  $477\ \mu$ ; width of basis capituli— $306\ \mu$ ,  $276\ \mu$ ,  $289\ \mu$ ; length of palp— $349\ \mu$ ,  $292\ \mu$ ,  $330\ \mu$ ; length of palpal article II— $175\ \mu$ ,  $146\ \mu$ ,  $158\ \mu$ ; length of palpal article III— $146\ \mu$ ,  $116\ \mu$ ,  $138\ \mu$ ; length of scutum— $1,470\ \mu$ ,  $1,410\ \mu$ ,  $1,428\ \mu$ ; width of scutum— $750\ \mu$ ,  $690\ \mu$ ,  $729\ \mu$ ; length of tarsus I— $422\ \mu$ ,  $348\ \mu$ ,  $388\ \mu$ ; length of metatarsus I— $204\ \mu$ ,  $189\ \mu$ ,  $192\ \mu$ ; length of pregenital plate— $292\ \mu$ ,  $233\ \mu$ ,  $262\ \mu$ ; width of pregenital plate— $218\ \mu$ ,  $146\ \mu$ ,  $180\ \mu$ ; length of median plate— $640\ \mu$ ,  $567\ \mu$ ,  $606\ \mu$ ; width of median plate— $480\ \mu$ ,  $407\ \mu$ ,  $448\ \mu$ ; length of adanal plate— $364\ \mu$ ,  $292\ \mu$ ,  $312\ \mu$ ; width of adanal plate— $233\ \mu$ ,  $189\ \mu$ ,  $199\ \mu$ ; length of anal plate— $320\ \mu$ ,  $276\ \mu$ ,  $284\ \mu$ ; width of anal plate— $292\ \mu$ ,  $218\ \mu$ ,  $254\ \mu$ . In some males the pregenital plate is incomplete at the apex, forming an irregular notch. A number of males bear two small collections of pits near the posterior margin of the basis capituli corresponding to the porose areas of the female.

*Nymph* (Plate II, *D*, *E*, and *F*).—Similar to female, light brown in color.

Capitulum, length  $364\ \mu$ ; basis capituli, width  $218\ \mu$ , posterior margin slightly convex, posterior lateral angles prominent, bluntly pointed; ventrally with prominent auriculae projecting posteriorly and ventrally, ventral posterior margin straight, without cornua or tubercles. Palpi long and slender (length  $320\ \mu$ ), articles II and III of equal length ( $146\ \mu$ ), article I with a prominent, sharp tooth projecting ventrally and somewhat laterally. Hypostome long and slender, pointed, 3 rows of teeth on each side, 6 teeth in inner rows, 9 in each of the outer 4 rows, with additional small teeth at the tip.

Scutum, length  $567\ \mu$ , width  $466\ \mu$ , widest near the middle, posterior margin broadly and evenly rounded; cervical grooves as in the female; a few scattered punctures.

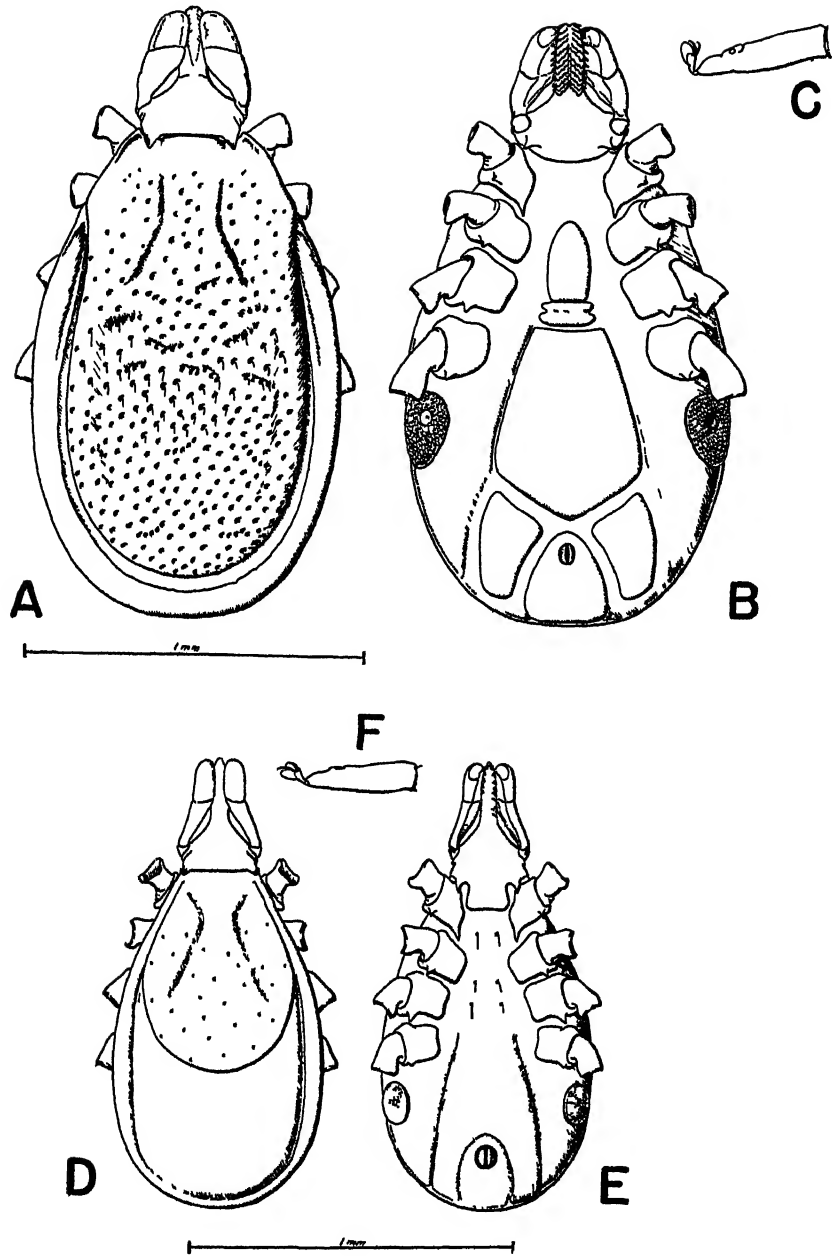
Legs, coxae, and tarsi similar to those of the female; tarsus I,  $276\ \mu$ , metatarsus I,  $131\ \mu$ .

Stigmal plates  $109\ \mu$  dorsoventrally,  $95\ \mu$  anteroposteriorly, macula near the center.

Body light brown, with a few pale hairs, marginal groove deep, anal groove as in the female.

#### EXPLANATION OF PLATE II

*Ixodes bishoppi* n. sp. *A*, Dorsal view of male. *B*, Ventral view of male. *C*, Lateral view of tarsus I of male. *D*, Dorsal view of nymph. *E*, Ventral view of nymph. *F*, Lateral view of tarsus I of nymph. Drawn by Arthur Cushman



*Larva* (Plate I, *D*, *E*, and *F*).—Capitulum light brown, length 233  $\mu$ ; basis capituli, width 146  $\mu$ , posterior margin straight, posterior lateral angles acute, slightly salient posterolaterally; ventrally with triangular auriculae projecting posterolaterally; posterior margin rounded, without cornua or tubercles. Palpi long and slender (length 175  $\mu$ ), articles II and III of equal length (80  $\mu$ , article I prominent ventrally. Hypostome with 3 rows of teeth on each side, 5 teeth in inner row, 9 teeth in outer rows.

Scutum, length 335  $\mu$ , width 378  $\mu$ , posterior margin broadly rounded. Cervical grooves shallow, narrow, converging then diverging, reaching the posterior margin of the scutum.

Tarsus I, 189  $\mu$ , metatarsus I, 87  $\mu$ , tarsi tapering more gradually than in the nymph. A long internal spur on coxa I, short external spurs on coxae I and II.

Body yellowish brown with a few pale hairs around the margin. Anal groove faint, less convergent posteriorly than in the female.

*Type*—No. 1519, U. S. National Museum, holotype female, allotype male, paratype male and female from Accession No. 17494, Dec. 24, 1943, Savannah, Ga., on cotton rat (collected as larvae and reared to adults.) Nymph and larva described from specimens reared from a female from Accession No. 17455, Oct. 7, 1943, Savannah, Ga., on cotton rat. Other paratypes deposited in the U. S. National Museum, as follows: 8 nymphs, 2 males, 2 females from Accession No. 17450, Sept. 22, 1943, Savannah, Ga., on cotton rat (collected as larvae); 1 female, No. 17453, Sept. 21, 1943, Savannah, Ga., on cotton rat; 1 male, 4 females (and many larvae and nymphs reared from one of the females), No. 17455, Oct. 7, 1943, Savannah, Ga., on cotton rat; 1 nymph, 1 male, 2 females, No. 17458, Oct. 13, 1943, Savannah, Ga., on cotton rat (collected as larvae); 2 males, 1 female, No. 17464, Nov. 20, 1943, Savannah, Ga., on house wren (collected as larvae); 1 female, No. 17471, Dec. 3, 1943, Savannah, Ga., on cotton rat (collected as nymph); 1 female, No. 17476, Dec. 14, 1943, Savannah, Ga., on cotton rat (collected as nymph); 1 female, No. 17495, Jan. 1, 1944, Savannah, Ga., on cotton rat (collected as larva); 1 nymph, 1 male, 1 female, No. 17516, Jan. 25, 1944, Savannah, Ga., on cotton rat (collected as nymphs); 2 females, No. 17531, March 13, 1944, Savannah, Ga., on cotton rat (collected as nymphs); 2 nymphs, 1 male, No. 32017, Jan. 16, 1943, Savannah, Ga., on cotton rat (collected as larvae and nymph); 1 male, 2 females, No. 32020, Jan. 23, 1943, Savannah, Ga., on cotton rat (collected as nymphs); 1 nymph, 1 male, No. 32022, Jan. 26, 1943, Savannah, Ga., on house mouse (collected as larvae); 1 larva, 1 male, No. 32023, Jan. 26, 1943, Savannah, Ga., on cotton rat (collected as larva and nymph); 6 nymphs, 1 male, 1 female, No. 32026, Feb. 2, 1943, Savannah, Ga., on towhee (collected as larvae and nymphs); 1 male, 2 females, No. 32079, April 4, 1943, Savannah, Ga., on cotton rat (collected as nymphs).

This species is most closely related to *Ixodes minor* which is recorded from *Hesperomys* sp. (*Peromyscus*: Muridae) in Guatemala. Other species of similar appearance are *I. dentatus* Neum., *I. muris*, *I. diversifossus* Neum., *I. spinipalpis* (Hadwen and Nuttall), *I. neotomae* Cooley, *I. peromysci* Augustson, and, in the immature stages, *I. scapularis* Say.

The female differs from that of *I. minor* in the tapering scutum, the anal grooves converging behind the anus, and the long ventral spine on palpal article I. It differs from *I. muris* in these same characteristics, and also in the ventrally projecting auriculac. It differs from *I. diversifossus* and *I. dentatus* in the longer and more tapering scutum, longer and more tapering basis capituli, less prominent lateral carinae, and the shorter internal spur on coxa I. It differs from *I. spinipalpis* in the longer and more tapering basis capituli, less prominent lateral carinae, and larger coxal spurs. It differs from *I. neotomae* and *I. peromysci* in the greater number of goblets on the stigmal plates and the shorter, less prominent lateral carinae. In the recent monograph of the Genus *Ixodes* by Cooley and Kohls (1945) this species would key to *I. neotomae*.

The male differs from that of *I. minor* in the notched hypostome, the relatively shorter basis capituli, palpal article II distinctly longer than article III, the presence of distinct auriculac, the position of the coxal spurs at the external angles of the coxae, and the wide marginal fold. It differs from *I. muris* in the presence of long cornua, prominent auriculac, curved ventral posterior margin of basis capituli, shorter adanal plates, narrower median plate, and larger external spur on coxa I. It differs from *I. dentatus* and *I. diversifossus* in the absence of internal spurs or tubercles on coxae II and III, the narrower median plate, and the anteriorly tapering pregenital plate. It differs from *I. neotomae* and *I. peromysci* in having more numerous and larger punctations on the scutum, more goblets on the stigmal plates, and more teeth on the hypostome. In Cooley and Kohls (1945) the male of this species keys to item 7, beyond which it does not entirely agree with either branch of the key.

The nymph differs from that of *I. muris* in the spine on palpal article I, and the anal groove converging behind the anus; from *I. dentatus* in the longer scutum, prominent auriculac, shorter internal spur on coxa I and longer cornua; from *I. spinipalpis* in the more sharply tapering auriculac, absence of lateral carinae, and converging anal groove; and from *I. scapularis* in the absence of ventral cornua, the auriculac broader and not projecting ventrally, more abruptly tapering tarsus I, and converging anal groove. The nymph of *I. minor* is unknown.

It differs from *I. neotomae* and *I. peromysci* in having more goblets on the stigmal plate and in the absence of lateral carinae.

The larva differs from that of *I. muris* in the absence of cornua and in the greater relative length of the capitulum; from *I. dentatus* in the pointed auriculac and the narrow cervical grooves; from *I. spinipalpis* in the greater relative length of the capitulum; and from *I. scapularis* in the absence of ventral cornua and the auriculac broader and not projecting ventrally. The larva of *I. minor* is unknown.

The authors take pleasure in naming the species in honor of F. C. Bishopp, in recognition of his contributions to our knowledge of the Ixodoidea.

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- Cooley, R. A., and Glen M. Kohls. 1945. The genus *Ixodes* in North America. U. S. Pub. Health Serv., Natl. Inst. Health Bul. 184, 246 pp., illus.

# RESISTANCE OF MOSQUITO LARVAE AND PUPAE TO EXPERIMENTAL DROUGHT

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Random field observations of anopheline larve in temporary puddles in New Guinea first called the problem of drought resistance to our attention as one of possible importance in mosquito control operations. We noted that following periods of relative drought rain puddles which had evaporated to the damp mud stage and were subsequently reflooded often contained numerous anopheline larvae in the late stages of development. Although the larval cycle of mosquitoes in the tropics is greatly accelerated it is an *a priori* consideration that these larvae must have survived the temporary drought on the damp mud in order to be of such advanced development shortly after "dry" puddles were flooded by rains. Preliminary field laboratory observations in New Guinea showed that fourth instar larvae of *Anopheles punctulatus* could survive for approximately 120 hours on damp filter paper flooded for thirty minutes at twenty-four hour intervals.

While considerable attention has been given to the drought resistance of eggs of various species of *Aedes*, little of significance has been published concerning the resistance of mosquito larvae to drought. Celli and Casagrandi (1899) reported that *Anopheles* larvae could survive on moist mud for 96 hours. In preliminary experiments Schoof, Schell and Ashton (1945) found that larvae and pupae of *Anopheles quadrimaculatus* survived in muck for 48 hours and that the pupae were more resistant to these conditions than the larvae. Headlee (1945) stated that pupae of *Aedes sollicitans* survive for 24 hours in soft mud and half grown larvae for only a few hours.

By the experiments described below we have attempted to determine under controlled laboratory conditions the effects of varying periods of drought and of periodic flooding on the vitality of the larvae of three species of mosquitoes: *Anopheles walkeri*, a species more or less restricted to the shaded grassy margins of swamps and lakes; *Aedes vexans*, a temporary pool inhabitant; and, *Wyeomyia smithii*, a species restricted to the water held in pitcher plants (*Sarracenia purpurea*).

For these experiments larvae of *Wyeomyia smithii* were collected from pitcher plants in the Lloyd-Cornell Reservation at McLean, N. Y., on May 10; larvae and pupae of *Aedes vexans* from a temporary pool near Varna, N. Y., on May 20, and from small temporary puddles in Ellis Hollow Swamp, Ellis, N. Y., on May 24; and, larvae of *Anopheles walkeri* from Cayuta Lake swamp, near Cayutaville, N. Y., on June 14.

## RESISTANCE TO CONTINUOUS DROUGHT

*Series I. Aedes vexans, fourth instar larvae.* Petri dishes were prepared by placing oversized filter paper in the bottom and adding sufficient water (2.5 cc.) to dampen the paper but yet allow no visible free water. Pond water from the sources of the collections was used

throughout. The experimental dishes were kept covered so that maximum humidity would prevail, but control dishes were left uncovered. Temperature in the laboratory ranged between 21° and 28° C.

Five larvae were added to each of 30 dishes and examined on the following schedule: 15 each after 24 and 48 hours, and 30 each after 72, 96, 120 and 144 hours of continuous drought. Six control dishes differed from the experimentals only in that they were flooded to a depth of about one-fourth inch and were examined every twenty-four hours.

The maximum survival time was 96 hours when 17 per cent had survived (Table I). At 48, 72 and 96 hours there was no significant difference in the per cent survival. Although the control group showed a daily decrease, the number surviving was always roughly at least twice as great as the experimentals.

TABLE I

RESISTANCE TO CONTINUOUS DROUGHT AND TO DROUGHT WITH PERIODIC REFLOODING

SERIES SPECIES	INSTAR	PER CENT SURVIVAL										
		Time Interval in Hours										
		24	48	72	96	120	144	168	192	216	240	264
I-C1 <sup>1</sup> <i>vexans</i> .....	4	87	70	47	30	30	30	27	....	....	....	....
I-Drt. ".....	"	80	13	17	17	0	....	....	....	....	....	....
I-Rfl ".....	"	80	7	0	....	....	....	....	....	....	....	....
II-C1 <i>vexans</i> .....	3	100	100	100	87	83	77	....	....	....	....	....
II-Drt ".....	"	90	37	43	17	20	....	....	....	....	....	....
II-Rfl ".....	"	90	67	50	30	17	7	....	....	....	....	....
III-C1 <i>vexans</i> .....	1 & 2	90	90	90	....	....	....	....	....	....	....	....
III-Drt ".....	"	....	36	....	....	....	....	....	....	....	....	....
IV-C1 <i>smithii</i> .....	4	100	100	92	83	75	42	42	33	33	....	....
IV-Drt ".....	"	....	83	....	58	....	48	....	83	....	....	....
IV-Rfl ".....	"	....	83	50	42	33	33	33	33	33	....	....
V-C1 <i>walkeri</i> .....	4	100	100	100	100	100	100	87	87	87	80	73
V-Drt ".....	"	100	73	80	67	27	0	....	....	....	....	....
V-Rfl ".....	"	73	73	67	60	53	40	33	13	7	7	0

<sup>1</sup>C1=control group; Drt=continuous drought; Rfl=drought with periodic reflooding.

*Series II. Aedes vexans, third instar larvae.* The same number of larvae and dishes were used and set up as in Series I. Examination was on the following schedule: 30 larvae each after 24, 48, 72, 96 and 120 hours of continuous drought. Thirty control larvae were treated as in Series I.

The maximum observed survival time was 120 hours when the experiment was terminated (Table I). Survival of the intermediate time groups decreased irregularly to 20 per cent after 120 hours. The control series showed a slight daily decrease in the number of living larvae, nevertheless there was always a significant difference between them and the experimentals.



*Series III. Aedes vexans, first and second instar larvae.* One experimental dish of 14 larvae was examined after 48 hours of drought. A control dish of 10 larvae was treated as in Series I.

The maximum observed survival time was 48 hours, when the experiment was terminated (Table I). The 48 hour drought reduced survival to 36 per cent, approximately one-third that of the control group.

*Series IV. Wyeomyia smithii, fourth instar larvae.* Sixty larvae were set up as in Series I but with 12 to a dish, and examined on the following schedule: 12 each after 48, 96, 144 and 192 hours of continuous drought. A control dish of 12 larvae was treated as in Series I.

The maximum observed survival time was 192 hours when the experiment was terminated (Table I). Survival was strikingly irregular for the intermediate time groups. At 144 hours the per cent surviving in the experimental group was equal to that of the control, and at 192 hours only 33 per cent of the controls were living whereas 83 per cent of the experimental group had successfully resisted the eight days of drought.

TABLE II  
SURVIVAL OF *A. walkeri* LARVAE FOLLOWING CONTINUOUS DROUGHT

NUMBER LARVAE USED	PER CENT SURVIVAL										
	Time Interval in Hours										
	24	48	72	96	120	144	168	192	216	240	264
10.....	100	100	100	100	100	90	70	70	70	70	70
15 .. .		73	73	67	60	47	47	47	40	40	40
15 .. .			80	80	67	47	47	47	40	40	40
15 .. .				67	53	53	47	40	33	20	20
15 .. .					27	13	7	7	0		
15 .. .					0						

*Series V. Anopheles walkeri, fourth instar larvae.* One hundred larvae were set up as in Series I and examined on the following schedule: 10 after 24 hours, and 15 each after 48, 72, 96, 120 and 144 hours of continuous drought. After examination the dishes were kept flooded to determine possible injury to the larvae caused by the drought. Fifteen control larvae were treated as in Series I.

The maximum survival time was 120 hours (Table I). Mortality was quite limited up to 96 hours of drought and subsequent daily examination of these larvae indicated that drought had caused no significant injury. However, the 27 per cent which survived the maximum time were evidently injured and decreased to 7 per cent 48 hours after being returned to flooded conditions (Table II).

*Probable causes of death.* Microscopic examination of dead larvae was made during each period of observation and their apparent condition recorded. These observations showed that of all dead fourth instar *A. vexans* "larvae" (Series I) 58 per cent exhibited a humped thorax and/or pupal respiratory trumpets indicating that internal changes preliminary to pupation were well advanced. It seems that the cause

of death *per se* was not due solely to lack of free water but to a combination of this coincident with the internal changes preparatory to pupation. None successfully completed pupation.

Pupation was similarly critical for *W. smithii* (Series IV) but 66 per cent died as fully formed pupae which had been unable to completely free themselves of the fourth instar exuviae. That the larvae in the intermediate time groups were inadvertently older and reached the critical pre-pupation stage while subjected to drought may be taken as the probable explanation of the low survival recorded.

In contrast, no more than one per cent of the larvae of *A. walkeri* died as "prepupae." Apparently these individuals as a group were younger and scarcely any reached the critical pupation period during the experiment.

The molting process from third to fourth instar in *A. vexans* (Series II) was also critical, but at least three (two per cent) successfully accomplished this molt.

TABLE III  
EMERGENCE OF *A. vexans* IMAGINES IN CONTINUOUS DROUGHT

NUMBER PUPAE USED	SEX	NUMBER IMAGINES EMERGING			TOTAL	PERCENT OF TOTAL
		Time Intervals in Hours				
		24	48	72		
.....	♂	16	56	1	73	.....
.....	♀	10	28	6	44	.....
125	.....	26	84	7	117	94

#### RESISTANCE TO DROUGHT AND PERIODIC FLOODING

Following the same general procedures groups of larvae from each series were subjected to drought broken at 24 hour intervals by a thirty minute period of flooding. Fifteen fourth instar *A. vexans*, 30 third instar *A. vexans*, 15 fourth instar *A. walkeri* and twelve fourth instar *W. smithii* larvae were used.

It seems apparent that periodic flooding was of no obvious benefit to *A. vexans* and *W. smithii* larvae in surviving the drought, but larvae of *A. walkeri* survived 120 hours longer than those in continuous drought (Table I).

Conditions of death prevailed as in continuous drought. We had thought that periodic flooding would in some degree simulate slight tidal or rainfall fluctuations which would assist larvae in withstanding drought. Either this was not the case or the flooding should have been of longer duration to be of survival value to the larvae.

On the other hand periodic flooding may possibly have been detrimental. It was observed that larvae of *A. vexans* and *W. smithii* secreted a thin mucous covering during continuous drought, while those subjected to periodic flooding did not renew this mucous after the first flooding. Possibly the protective mucous covering was dissolved and the larvae were incapable of renewing it so frequently. No mucous secretions were observed on *A. walkeri* larvae.

## PUPAE

*Series VI. Aedes vexans, pupae.* One hundred and twenty-five pupae were set up as in Series I, the number in each dish depending upon the number available daily from the culture. Each dish was examined at 24 hour intervals and the number of imagines recorded. No control was used.

Imagines emerged from 94 per cent of the pupae. The maximum time of stranding was 72 hours, after which no emergences were recorded (Table III).

Pupae of the other species were not available.

## DISCUSSION

Some degree of correlation between the resistance to drought and the typical natural microhabitat of these species was noted. Conditions seem to be more favorable for frequent periods of drought in the pitcher plant microhabitat of *W. smithii* than in the larger bodies of water inhabited by *A. vexans* and *A. walkeri*. It follows that survival in pitcher plants requires some measure of drought resistance. Our experiments strikingly bear this out in showing larvae of *W. smithii* to be much more resistant to drought than either *A. walkeri* or *A. vexans*.

Our observations showed clearly that pupae of *A. vexans* were more resistant to drought than the larvae. Of major significance is the fact that lack of free water did not prevent emergence of the imago.

The practical implications of these experiments to entomologists engaged in mosquito control are obvious. Larvicide programs should be extended to include all damp depressions which may hold water periodically for relatively short periods of time.

## SUMMARY

1. Larvae of three species of mosquitoes (*A. vexans*, *W. smithii* and *A. walkeri*) were subjected to controlled drought in the laboratory.
2. The maximum survival time of *A. vexans* under continuous drought was determined to be 120 and 96 hours respectively for third and fourth instar larvae.
3. The maximum observed survival time of *W. smithii* larvae under continuous drought was 192 hours.
4. The maximum survival time of *A. walkeri* under continuous drought was 120 hours.
5. Periodic flooding for 30 minutes at 24 hour intervals was of no obvious benefit to *A. vexans* and *W. smithii* larvae in surviving drought, but considerably prolonged survival of *A. walkeri* larvae.
6. Imagines emerged from 94 per cent of *A. vexans* pupae under drought conditions.
7. Larvicide programs should include depressions in the damp mud stage which may subsequently be flooded.

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# TAXONOMIC STUDIES ON THE EPHEMEROPTERA

## IV. THE GENUS STENONEMA

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The genus *Stenonema* is abundant and ecologically widely distributed in North America east of the Rocky Mountains. The flattish nymphs of one or more species are to be found in most permanent bodies of water in which currents are set up either by wind action or by gravity. For a number of years I have been accumulating material for a generic revision. The taxonomy of the group is involved and it is apparent that considerable rearing of imagoes from their respective nymphs must be undertaken before some of the problems can be solved. *Stenonema* docs, however, consist of three distinct complexes or groups of species. For two of these, i. e., *tripunctatum* and *interpunctatum*, enough data have been accumulated by various investigators as well as by the author that a rather clear picture can be presented at this time. The third complex, *pulchellum*, consists of numerous closely related species and subspecies and presents many puzzling questions. To solve the problems presented in the last named complex, imagoes must be reared from various parts of the geographical ranges of the sundry species, a type of investigation which proceeds slowly and demands the co-operation of numerous students of the ephemeroidea. I hope that this preliminary paper may stimulate such endeavors and that eventually we shall be able to compose a complete picture of the taxonomy of the group from its entire range. The present work is restricted to a general discussion and delimitation of the genus plus taxonomic revision of the *tripunctatum* and the *interpunctatum* complexes.

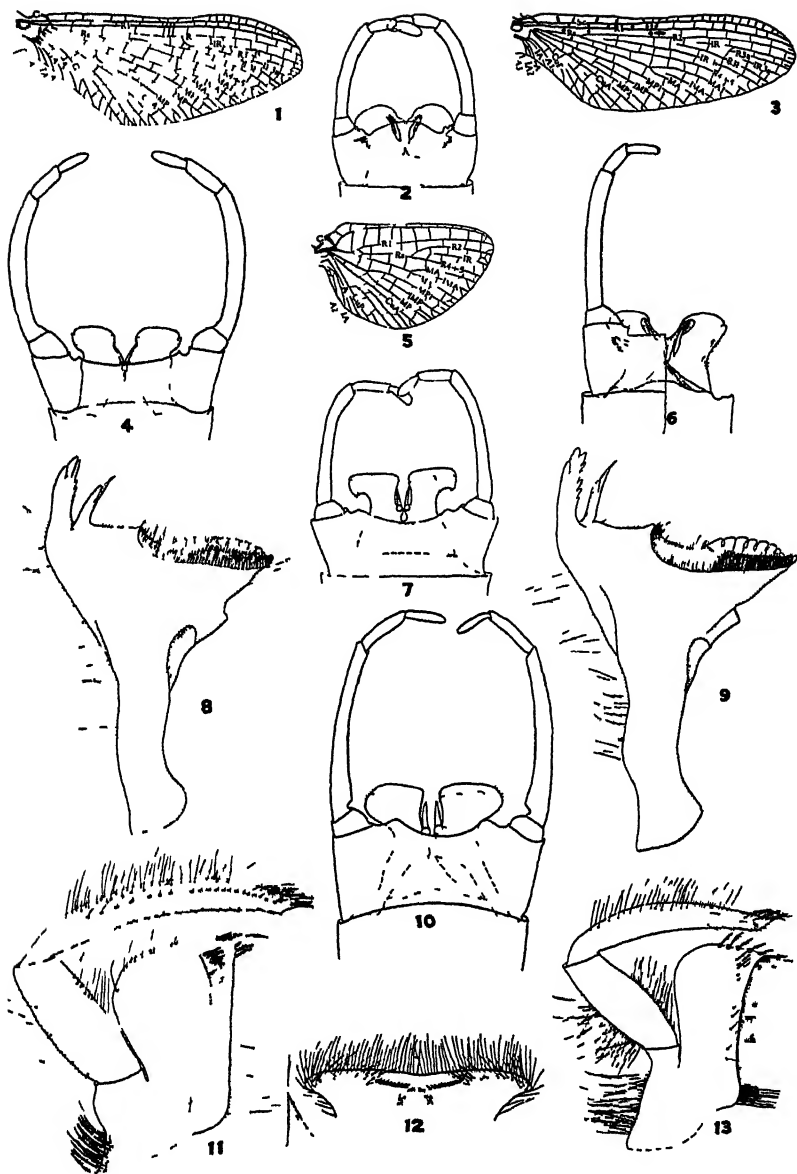
In preparation for this paper I have seen the collections and types for the genus which are deposited in the British Museum (Natural History) Collection, the Canadian National Collection, the Cornell University Collection, the Illinois Natural History Survey Collection, the Museum of Comparative Zoology Collection as well as those in the American Museum of Natural History Collection and, of course, in my own personal collection. I wish to thank the various officers and scholars of the above institutions for courtesies extended to me. Special thanks are due the American Museum of Natural History, and particularly the late Dr. Frank E. Lutz, for research facilities. Dr. Mont A. Cazier suggested the utilization of the statistical techniques that have been applied to the *interpunctatum* complex. His aid and advice, as well as that of Miss Annette Bacon, have been invaluable. Any errors in the use of these techniques or of interpretation should, however, be charged solely to the author. Finally, I should like to say that detailed distributional records have not been given at this time for two reasons: (1) Because they are as yet incomplete, and (2) in order to save printing space. I do, however, have detailed records of emergence dates, localities, etc., in note form.

Genus *Stenonema* Traver

*Imago*.—Compound eyes of male moderately large; separated dorsally by about the diameter of a laterally situated ocellus; eye of female flattened and separated by distance greater than diameter of eye; the posterior margin of the female head weakly excavated. Pronotum strongly excavated posteromedially; lateral lobes reflexed. Fore leg of male as long as or longer than body. Tibia one and a quarter to one and one-third times as long as femur; fore tarsi approximately one and one-third times as long as tibia. First fore tarsal joint typically about one-half as long as second. In some individuals of *S. interpunctatum heterotarsale*, however, it is almost as long as second joint. Third segment subequal to second; fourth shorter than third but longer than first; fifth slightly shorter than first. Ranked in descending length, the tarsal segments of male are 2, 3, 4, 1, 5. Fore leg of female shorter than body; fore tibia subequal to femur; tarsus shorter than tibia; first tarsal joint one-half to three-quarters as long as second; third subequal to second; fifth subequal to third but longer than first, and fourth shorter than fifth. Ranked in descending length, the fore tarsal segments of female are 2, 3, 5, 1, 4. The femur of the metathoracic leg of both sexes is subequal to or slightly longer than the tibia; the tarsus about one-half of the tibia. Metathoracic fifth tarsal joint longest; in the *interpunctatum* and *tripunctatum* complexes the first joint is subequal to the second; the third is subequal to the first and the fourth is shortest. Thus the arrangement in descending lengths is 5, 2, 1, 3, 4. Species of the *pulchellum* complex are similar except 2 is subequal to 1 so that the arrangement is 5, 1, 2, 3, 4. Claws dissimilar on all tarsi. Typical Heptagenine venation in fore wing (figs. 1 and 3). Basal cross veins well developed. Stigmatic veins normally showing no anastomosing but may be slightly aslant. Cross veins of bullar area may or may not be crowded. Typical Heptagenine venation in hind wing (fig. 5). Between the CuA and CuP a pair of elongated marginal intercalaries. Sometimes an elongated marginal veinlet in front of the normal pair and another behind gives the appearance of two pairs of intercalaries in the cubital area of the hind wing. Male genitalia (figs. 2, 4, 6, 7 and 10) with four-jointed forceps; penes deeply divided with a strong spine on the inner side of each division. Members of the *interpunctatum* complex with penes shaped as in figs. 2, 4 and 6; in all others shaped somewhat as in figs. 7 and 10. Posterior margin of styliger plate straight or slightly convex in the *interpunctatum* complex; slightly excavated in all others. Subanal plate of female well developed, extending at least as far as tip of dorsum of abdomen; may be slightly excavated on distal margin. Median pseudocercus completely absent.

## EXPLANATION OF PLATE I

1. Fore wing of *S. femoratum tripunctatum*. 2. Male genitalia of *S. interpunctatum interpunctatum*. 3. Fore wing of *S. interpunctatum interpunctatum*.
4. Male genitalia of *S. carolina*. 5. Hind wing of *S. femoratum tripunctatum*.
6. Male genitalia of *S. gildersleevei*. 7. Male genitalia of *S. pulchellum*.
8. Mandible of *S. rubromaculatum*. 9. Mandible of *S. interpunctatum interpunctatum*.
10. Male genitalia of *S. femoratum femoratum*. 11. Maxilla of *S. femoratum femoratum*.
12. Labrum of *S. interpunctatum frontale*. 13. Maxilla of *S. itasca*.



*Nymph*.—Moderately flattened Heptagenine type. Head large, flattened, and wider than long with posterior margin slightly excavated. Mouthparts completely ventral; labrum (fig. 12) broad with smooth front margin; mandibles (figs. 8 and 9) slender, incisors moderately large with inner member somewhat smaller than outer; inner incisors asymmetrical, right one (fig. 17) possessing a sharp, sturdy spur which is not developed on the left member. Lacinia mobilis (fig. 18) a large, slender seta found only on left mandible and often it may be broken. Maxillae (figs. 11, 13 and 14) with two-jointed palp, the distal segment of which is sparsely setose except on outer distal surface where a denser mass of simple, long, slender setae are found. Galea-lacinia widest distally; inner lacinial edge with dense stockade of simple setae; lateral to lacinial edge is row of somewhat evenly spaced plumose setae; distal lacinial dentes slender; distal margin of galea with a variable number of heavy setae that vary from hemiplumose spines (*ihaca*) to sturdy combs (*interpunctata*). Hypopharynx (fig. 21) with wing-like superlinguae. Labium (fig. 15) typically heptagenine.

Prothorax with lateral extensions that do not extend back past the anterior margin of the mesothorax. Legs flattened and tarsal claws with or without pectinations.

Gills carried dorsally and not utilized as an adhesive organ; gills one to six (figs. 20, 22, 23 and 25) double; seventh gill (figs. 16, 24 and 27) single, slender and lanceolate, lacking fibrillar portion. Tracheal branches may or may not be present in this seventh gill. Posterior lateral abdominal spines variable. Pseudocercus and two lateral cerci present.

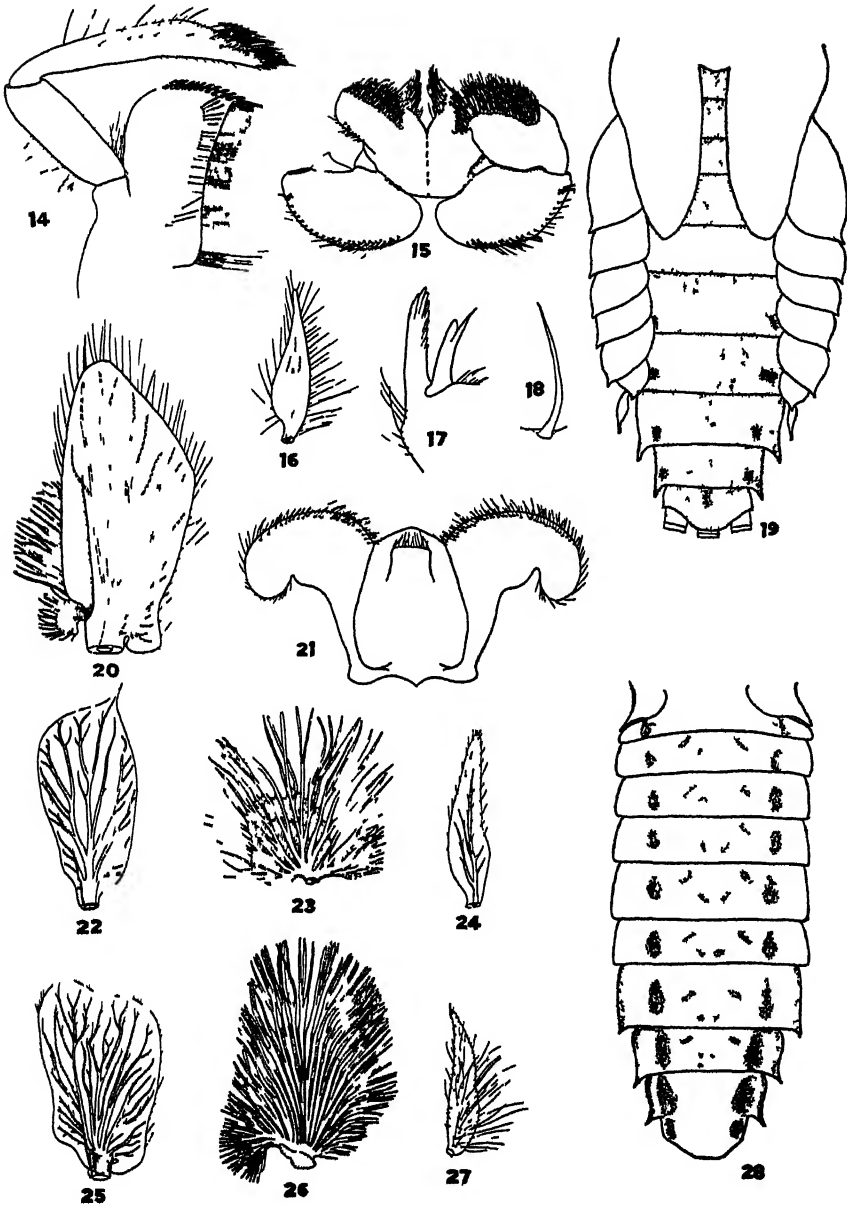
*Genotype*.—*Stenonema tripunctatum* (in *Heptagenia*) Banks.

#### REMARKS

This genus was erected by Traver (1933) to include certain American species that Eaton had placed in *Heptagenia*, *Ecdyonurus* and genus incerti. Some investigators had considered these species to be members of the genus *Heptagenia* (Banks, Needham, and Clemens) while McDunnough and others had placed them in *Ecdyonurus*. Ulmer (1939 and 1940) considers *Stenonema* to be a synonym of *Heptagenia*. He concludes this from the factual basis that his *Heptagenia nasula* adults from Borneo have fore tarsal segments similar to those of *Stenonema* while the genitalia are similar to certain species that are included in *Heptagenia*. If we follow Ulmer, *Heptagenia* contains a large number of species, some of which obviously are phylogenetically quite widely diverse. The genus becomes large and unwieldy with the resultant

#### EXPLANATION OF PLATE II

14. Maxilla of *S. interpunctatum interpunctatum*. 15. Labium of *S. interpunctatum canadense*. 16. Seventh gill of *S. femoratum tripunctatum*. 17. Detail of right incisors of *S. fuscum*. 18. Lacinia mobilis of *S. pulchellum*. 19. Dorsal view of nymphal abdomen of *S. interpunctatum frontale*. 20. Third gill of *S. femoratum femoratum*. 21. Hypopharynx of *S. fuscum*. 22. Dorsal gill lamella of *S. interpunctatum*. 23. Ventral gill lamella of *S. interpunctatum*. 24. Seventh gill of *S. interpunctatum interpunctatum*. 25. Dorsal gill of lamella of *S. ihaca*. 26. Ventral gill lamella of *S. ihaca*. 27. Seventh gill of *S. pulchellum*. 28. Ventral view of nymphal abdomen of *S. interpunctatum frontale*.





obscuring of phylogenetic relationships. Further, if we accept Ulmer's definition of the genus *Heptagenia*, we must either (1) synonymize the genus *Ecdyonurus* as it is now delimited into the genus *Heptagenia*, or (2) divide *Stenonema* as defined by Traver between *Heptagenia* and *Ecdyonurus*. The reasons for these alternatives are as follows. The only way imagoes of *Heptagenia* (in Ulmer's sense) and *Ecdyonurus* can be separated is that in the latter the first segment of the metatarsus is longer than the second, while in the former the second metatarsal segment is longer than the first. On this basis the *pulchellum* complex would belong to *Ecdyonurus* and the *interpunctatum* and *tripunctatum* complexes to *Heptagenia*. Such a procedure would be unwarranted since we have adequate evidence from both nymphal and adult material that these three complexes are monophyletic in origin. The alternative is to fuse *Ecdyonurus*, *Stenonema*, and *Heptagenia* into a single huge genus, which would further complicate the problem of elucidating phylogenetic relationships.

The answer to the question of generic delimitation is always a difficult one for taxonomists, especially in groups such as the heptageniids where the genera appear to be closely related. The following basic factors appear pertinent to any decision that may be reached concerning *Stenonema*, *Ecdyonurus* and *Heptagenia*:

1. We assume tacitly, upon the basis of morphological evidence primarily, that all species that belong to the family Heptageniidae are of monophyletic origin. From this ancestral stock various stocks have differentiated and some of these in their turn have further differentiated, and so on.

2. Since the various species that belong to each family or to each genus have descended from a single ancestral stock, we should expect the species to have many characters that are common to all and only a few that are different. Thus the set of characters found to be possessed by any single species of the family overlaps in large part the set of characters of any other species. Conversely the characters that differentiate them from another are few in number. Further, the differences between the various species or genera within a family tend to be restricted to a given set of structures. Thus, in Heptageniidae the tarsal lengths, the penes, and certain mouthparts (but not the forceps or the abdominal gills) have apparently undergone repeated modification. To put it another way, certain characters within any given stock seem to be highly susceptible to modification and to have independently become modified many times within a stock. Other characters, and by far the greater number, remain stable and are thus similar in all individuals of the stock. Such a view has received additional support from the accumulated evidence on the mutations of such organisms as *Drosophila* where the various species have many homologous mutations.

3. We also should, to the best of our ability, be sure that all of the species included in any given genus belong to the same phylogenetic substock.

It is obvious from what has been outlined above that all categories above the species are human concepts. True, such a category as the genus should always and usually does represent a monophyletic group, but the pertinent thing is that it does not exist in nature but merely as

a concept in the human mind. An author, in establishing a genus, although he may not say it in so many words, arbitrarily chooses a locus in the phylogenetic descent of a stock and says that all species which have differentiated since this locus shall belong to the genus. His choice of a locus is naturally determined by the material at hand, namely the specimens and sundry information known about the various species. Obviously various workers may choose different loci on the phylogenetic stem. Such things as the number of species, the apparent

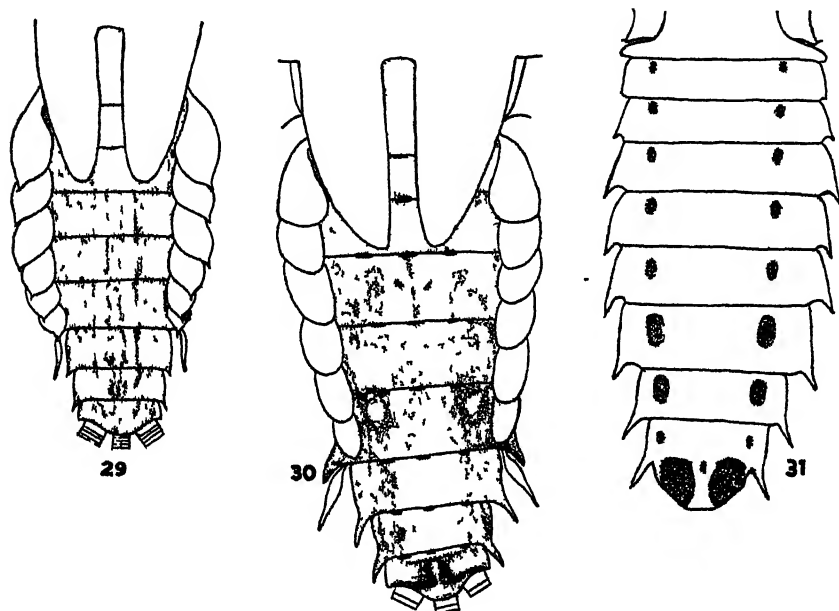


FIG. 29. Dorsal view of nymphal abdomen of *S. interpunctatum canadense*.

FIG. 30. Dorsal view of nymphal abdomen of *S. femoratum tripunctatum*.

FIG. 31. Ventral view of nymphal abdomen of *S. femoratum tripunctatum*.

homogeneity or non-homogeneity of the various species, the completeness of the information about the species, their geographical distribution, etc., will all play a part in the investigator's decision. All of these various principles have, of course, been offered time and time again by various writers and are in no sense original. I have restated them merely as a basis for the discussion of the present problem, i. e., the validity or non-validity of the genus *Stenonema*.

As defined by Traver and redefined above, the genus *Stenonema* consists of a moderate number of species that all live within a clearly delimited geographical area. All of these species have a common set of characters which they display during the various stages of their life cycles that distinguish them from other known species. The genus as defined is not unwieldy; it helps to elucidate the phylogeny within the family to which it belongs, and from all present information contains a group of species which are monophyletic in origin.

Finally, it should be noted that Ulmer (1939) added to the difficulties of the nomenclature of the wing venation by misinterpreting the cubital venation of all members of the family Heptageniidae (Ecdyonuridae of Ulmer). Needham, Traver, Hsu, etc. (1935), p. 120) state that in the hind wing "the cubital fork is extended to the wing base. Its intercalary is extended to the base also, so that the cubital triad has come to appear as three complete, subparallel, independent veins." Ulmer does not agree with this interpretation and maintains that in most heptageniids the cubital is represented by a single vein. After much study I am forced to conclude that I can not agree with either point of view. Careful comparison of the venation of the fore and hind wings shows that in generalized genera such as *Siphonurus* and in those genera of the family Heptageniidae that I have studied (*Stenonema*, *Heptagenia*, *Iron*, *Ironopsis*, *Cinygmula*, *Paegnoides*, and *Thalerosphyrus*) the cubitals of the hind wing consist of *two veins*, a high or convex anterior CuA and a low or concave posterior CuP. Between these two veins detached marginal veinlets may be found as in *Stenonema*, or may be absent as in *Paegnoides*. Note that I have used the terminology advanced by Lameere (1922). This has been done because I am convinced that confusion will always exist about ephemerid venation until Lameere's views and nomenclature are utilized. As a concrete example, if either Needham and Traver or Ulmer had followed Lameere, they would not have faced the difficulties they did in interpreting the cubital veins of the hind wings of the heptageniids and other generalized forms.

#### BIOLOGY

The flattish nymphs of *Stenonema* are negatively phototactic and positively thigmotactic. They are normally to be found during the day time on the under sides of stones, boards, shells, etc. Although some, such as *Stenonema tripunctatum* and *S. interpunctatum*, are found in lakes, they all seem (at least during the warmer months of the year) to demand a habitat in which currents exist, due either to gravity as in streams or to winds as in lakes. So far as known, they do not live in bodies of waters which are almost, if not completely, devoid of currents, i. e., small ponds, etc. None of them, however, can ever tolerate the torrents. Thus they are normally found in regions of moderate currents.

In lakes the nymphs are found during the summer months in shallow waters and usually close to the shore. In large rivers they are congregated in areas such as rapids and falls and are almost, if not completely, lacking in the intervening quiet waters. During the colder months of the year, the nymphs (both lake and stream forms) are found in the deeper regions. In the case of the lakes that completely freeze over, the nymphs then live in an area where no currents are found.

The nymph feeds by sweeping, scraping and tearing detritus, diatoms, algae, etc., from the substratum. This is accomplished by highly efficient mouthparts.

So far as is known, no species has an egg which undergoes a diapause. The embryonic development proceeds continuously from the time the egg is deposited. Ide (1935a, p. 63) has, however, ascertained that the eggs of three females of *S. interpunctatum canadense*, all deposited at the same time and maintained under identical conditions, continued to

hatch over a period of six weeks. Further the rate of embryonic development seems dependent upon the temperature of the water, being slowed down during periods of lower temperatures. In any case the individuals overwinter as nymphs. Ide (1935b) has studied the nymphal development of *S. interpunctatum canadense*, *S. femoratum tripunctatum* and *S. fuscum*. He studied *canadense* most intensively and although unable to ascertain exactly how many instars it passed through (he identified thirty-five with certainty), it appears that it must shed its cuticula between forty and forty-five times during nymphal development.

The nymph, when ready to emerge, comes to the surface. Apparently some individuals may adhere to some object and partially crawl out of the water, while others emerge without any support. In the latter instances, the emerging subimago utilizes the nymphal exuvia as a raft. So far as is known, none emerges under the water as is found in the genera *Iron* (Ide, 1930) and *Ecdyonurus* (Kimmings, 1941).

After emergence, shedding of the subimaginal pellicle and the nuptial dance, all of which follow the standard ephemerid pattern, the female then deposits her eggs. These are extruded a few at a time from the oviducal openings as the female flies back and forth over the body of water into which she oviposits. Now and then she comes very close to the surface and depresses the abdomen in such a way that it touches the water and the eggs are loosened and washed off. This procedure is repeated many times.

Two types of eggs are found in the genus. The primitive *interpunctatum* complex has ellipsoid eggs with a coiled thread at each pole. In the *tripunctatum* and *pulchellum* complexes, the eggs are ellipsoid but lack the threads and have a gelatinous coat that swells when the egg is deposited in the water.

In the northern part of the range there is normally only one generation a year. Ide (1935a, p. 36) has shown, however, that under abnormal conditions there may be two generations each year. Further south in the range, there seems to be in some species at least two generations per year. Our information on this point is meager.

#### TAXONOMIC CHARACTERS

As with many ephemerids, imaginal coloration is of considerable importance in this genus. Its coloration conforms with the widespread tendency that has been set forth earlier (Spieth, 1938), namely, that those species which emerge during the spring and early summer are more darkly pigmented than are close relatives that emerge during the summer and early fall. In species of *Stenonema* which emerge over a comparatively long period of time, i. e., *tripunctatum*, the early individuals are much darker than are those that emerge later. In such species a few dark individuals, however, can be observed sometimes in the later part of the season. Whenever this occurs, it is apparently due to the fact that a smallish, spring-fed, cool stream is tributary to a larger, warm body of water. Thus the individuals that matured in the small, cold streams are exposed to the same factors as the dark forms that emerged much earlier from more normal streams in the same vicinity.

The color pattern itself is helpful but often the presence of the generalized melanistic coloration may obscure the pattern. In the wings,

pigmentation (in the form of dashes and infuscations around the cross veins) is of some aid. Color, however, is always variable no matter where or when found.

Structurally the arrangement of the cross veins, particularly the crowding or non-crowding in the region of the bulla, the length of the fore and hind tarsal segments, the ratio of the first to second fore tarsal joint, the ratio of the first tarsal joint to the fore wing length, the shape and spination of the genitalia as well as the size of the individuals, are of value. These are highly variable even to the point of varying between the two sides of the body in the case of bilateral structures, while wing length and body length show great seasonal variation. The paucity of reliable imaginal characters is one of the reasons why so much difficulty has been experienced in the taxonomy of the genus.

In the nymph, the mouthparts, especially the maxillae, the abdominal gills, the posterolateral spines of the abdominal segments, and the tarsal claws, are structural characters that are of considerable value. Again, however, we must depend primarily upon color pattern and coloration. As in the adult this must be employed with caution. Finally geographical origin and emergence time are helpful factors that can be utilized.

#### *Stenonema tripunctatum* complex

This complex consists of one species, *S. femoratum*, represented by three subspecies, i. e., *femoratum* Say, *tripunctatum* Banks, and *scitulum* Traver. All of them are restricted mainly to the Mississippi and St. Lawrence drainages although both *femoratum* and *tripunctatum* are found east and south of these two river systems. In the Mississippi drainage and the western part of the St. Lawrence system they, especially *tripunctatum* and *femoratum*, occupy the ecological and to a great extent the seasonal niche that *Stenonema vicarium* and its relatives fill in the eastern part of North America.

Taxonomically the imagoes of these subspecies are difficult to handle because practically all the structural characters and the color pattern are similar intersubspecifically, and extremely variable intrasubspecifically. If it were not for the characters of the wings, all subspecies would unquestionably be merged into one. In addition geographical ranges and emergence periods of the three broadly overlap.

On the basis of present information the complex is represented in Canada, Minnesota, Wisconsin and Michigan solely by *tripunctatum*. In Illinois, Indiana, Ohio, and New York both *femoratum* and *tripunctatum* are present and I have seen intergrades from all these states except Illinois. Both of these subspecies extend further south and also intergrade where they are found together, i. e., Georgia, Oklahoma, and North Carolina. However, in part of this area the picture is further confused by the presence of the third subspecies *scitulum*. It is separated from *femoratum* by emerging after the *femoratum* emergence period, but does intergrade with *tripunctatum*. Thus intergrades of *scitulum* and *tripunctatum* are known from Texas, Alabama, Kansas, Oklahoma, West Virginia, Illinois, Indiana and Ohio. Our knowledge is as yet quite incomplete as to the exact ranges of these three subspecies.

In general, *femoratum* is an early spring form that occupies the area east of the Mississippi, south of the Great Lakes, and west of the Hudson River, and extends into the southern Piedmont; *tripunctatum* occupies the upper and middle Mississippi and St. Lawrence drainages and follows *femoratum* in emergence time; *scitulum* is restricted to Oklahoma, Kansas, Missouri, Illinois and Indiana, emerging from early summer to late fall. *S. femoratum scitulum* and *S. femoratum femoratum* both prefer streams, perhaps exclusively, while *tripunctatum* prefers lakes but also lives abundantly in streams.

Perhaps the last extensive glaciation is responsible for this confused picture. Unquestionably during that period *femoratum* was unable to live in much of the area which it now occupies. In the unglaciated parts of southeastern North America there probably dwelt at that time, especially in the uplands, the *femoratum femoratum* stock. This stock varied from very darkly pigmented early spring emergents to much lighter *tripunctatum*-like late season individuals. Westwardly, this stock was replaced geographically by a *femoratum scitulum* stock, early emergents (seasonally) and lighter colored than the corresponding individuals of *femoratum femoratum*. With the retreat of the glacier, large areas were opened to colonization. We have considerable evidence, especially in *Hexagenia*, that the south central and southwestern populations of ephemerids moved into this area which was exposed by the retreating glacier much faster than did the southeastern stocks. Probably it was mostly a question of drainage patterns which naturally determined the availability of routes of migration. It should be recalled that a river formed by the Wabash, lower Ohio and Mississippi formed an important, perhaps the main stream that drained the water from the glacier. When these two stocks moved back into the exposed region, the *scitulum* stock advanced most rapidly and the *femoratum* stock more slowly. From these immigrating stocks developed *tripunctatum*, but primarily *tripunctatum* seems to be derived from *scitulum*. Thus in the original territories *scitulum* and *femoratum* are still found, and both intergrade with *tripunctatum* but *tripunctatum* being primarily derived from *scitulum* shows greater similarity to that stock.

The complex is characterized as follows:

*Eggs*.—Ellipsoid without chorionic markings or threads, but with a gelatinous adhesive covering that swells into a thick coat upon contact with the water.

*Nymph*.—Sturdy, flattened stenonemids; galear portion of maxilla with two or three finely dissected setae on distal margin; second segment of maxillary palpus as in fig. 11; dorsal lamellae of gills 1-6 (fig. 20) elongate and rounded distally; 7th gill (Fig. 16) relatively sturdy, hairy and with a single trachea which may branch once; abdomen (fig. 30) with posterolateral spines on 3-9, slender 8th one longest, 9th similar in shape to 8th but shorter; spines on 3-7 stubby.

*Imago*.—Sturdy stenonemids which range in color from deep raw umber to pale creamy white; mesothoracic cross veins of costa, subcosta and radius always crowded in region of bulla, often margined with dark pigment; no transverse dashes of color in wings; genitalia (fig. 10) L-shaped; abdominal tergites 2-8 with three transverse dark dashes on posterior margin.

*Stenonema femoratum femoratum* Say

*Baetis femorata* Say, Western Quart. Reporter 2 (11): 162, 1823. Leconte, Complete Writ. T. Say 1: 171, 1857.

*Ecdyonurus femoratus* Say. McDunnough, Canad. Ent. 57: 190, 1925.

*Stenonema femoratum* Say. Travel, Biol. Mayflies, p. 311, 1935.

*Subspecific Characteristics; Male imago*.—General coloration raw umber; head and thorax raw umber with yellowish and fuscous markings; mesoscutum yellow; coxae raw umber; meso- and metafemora yellow, fore femora darker; all femora with medial and distal dark bands; all tibia with proximal darker band; longitudinal wing veins dark, immaculate and fine; mesothoracic cross veins a translucent burnt umber, robust and heavily margined with raw umber; mesothoracic cross veins at bullar region crowded in first six spaces (from costal margin to the M A), with the raw umber infuscations fusing to form a vertical streak in wing membrane; pterostigma burnt umber fading to pale raw umber distally; metathoracic wing with fine cross veins and raw umber apical cloud. Abdominal tergites 2-8 with three transverse black dashes, a median and a lateral on each side, on posterior edge; stigmal spots usually robust; tergites 2-7 yellowish brown, darker distally and laterally; 8, 9, and 10 much darker; sternites yellow, much lighter than tergites, unmarked except for faint ganglionic spots and the outer edge of 10th sternite; genitalia as in fig. 10; cerci smoky yellow, annulate with alternate segmental bands darker and broader; fore wing length 10-13 mm.

*Female imago*.—Similar to male except for dimorphic differences; fore wing length, 13-17 mm.

*Variations in imagoes*.—Specimens of *femoratum* which emerge very early in the spring display less variation than those which appear later. The general intensity of the coloration in this subspecies is relatively constant and variability is restricted mainly to the abdominal stigmal markings which vary in all degrees from large, robust ones to complete absence. Likewise the crowding of the cross veins in the bullar area, the amount of infuscation along the cross veins and finally the size of the apical cloud of the hind wing are subject to fluctuation. *S. femoratum* shows intergradation with *tripunctatum* which lives in the same area but emerges later, and thus some specimens may be placed either as dark *tripunctatum* or light *femoratum*.

*Nymph*.—Differs from all other known members of the *tripunctatum* complex in having the anterior margin of the head emarginate; abdominal sternites typically without the round dark spots that are characteristic of *tripunctatum*; abdominal tergal pattern as in *tripunctatum* but often much obscured even to the extent of lacking the characteristic light areas, especially the one on segments 7, 8, 9, and 10, and thus the entire dorsum appears uniform.

*Variations in nymph*.—The early spring emergents, i. e., the typical *femoratum*, have the dorsal abdominal pattern obscured and the ventral spots absent or present only on the posterior segments. As the season advances the mature nymphs appear more like the typical clear-cut *tripunctatum* pattern. Examples showing various degrees of intergradation between typical nymphs of *femoratum* and *tripunctatum* have been found.

*Holotype*.—The type material, which has subsequently been destroyed, was collected by Thomas Say at Cincinnati, Ohio, about the middle of May.

*Known distribution*.—Illinois, Indiana, Ohio, New York, and Georgia.

*Remarks*.—This robust, dark, early spring subspecies can be distinguished by the infuscation along the cross veins of the fore wing and the crowding and number of the cross veins in the bullar area from the fore margin to  $MA_1$ . This, combined with the infuscation, creates a dark band in the fore wing. The sturdy, chunky nymph is identifiable by the emarginate front edge of the head, the lack of ventral abdominal spots and the obscured dorsal pattern. The nymph appears to be a denizen of small, cool streams which probably accounts for the fact that Say found it to be scarce at Cincinnati. There exists the possibility that the differences between *femoratum* and *tripunctatum* are due to environmental rather than genetic influences. This subspecies has been associated sometimes with *pudica* Hagen. Actually there is no close relationship here; the resemblances are purely superficial. *S. pudica* is really a close relative of *Stenonema vicarium* which in turn belongs to the pulchellum complex.

Say's specimen, as McDunnough has suggested, was probably an imago. If individuals are studied in the clear daylight by means of a hand lens, the wings often, as Say indicates, appear milky. Under a binocular with strong light, this appearance disappears. In reading and checking any original description, it is always helpful to try to utilize the same magnification and lighting that the original investigator used.

### ***Stenonema femoratum tripunctatum* Banks**

*Heptagena tripunctata* Banks, Canad. Ent. 42: 199, 1910. Clemens, Canad. Ent. 45: 255, figs., 1913.

*Ecdyonurus tripunctatus* Banks. McDunnough, Canad. Ent. 65: 59, 1933.

*Stenonema tripunctatum* Banks. Traver, Biol. Mayflies, p. 332, 1935.

*Stenonema birdi* Traver, Biol. Mayflies, p. 306, 1935.

*Subspecific Characteristics; Male imago*.—General coloration highly variable, ranging from raw umber to creamy white; except for wings the color pattern and all structures are similar in all respects to *femoratum*, from which it varies only in the reduced intensity and tone of coloration. Mesothoracic wings with cross veins slightly, if at all, infuscated, with the bullar region having only those cross veins in the costal, subcostal and radial areas crowded and with the general intensity of coloration paler than in *femoratum*. Otherwise, wing as in *femoratum*. Metathoracic wings without apical cloud and with all veins pale or almost so; fore wing length, 10–13 mm.

*Female imago*.—Similar to male except for dimorphic differences; fore wing length, 13–17 mm.

*Variations in imagoes*.—The amount of color variation is large. The early spring forms are dark and only by drawing an arbitrary line can they be separated from *femoratum*. Late summer specimens are extremely pale, lacking all dark tints except for the pterostigmal area of the fore wing and the medial dashes on the posterior margins of the abdominal tergites. Such specimens often lack the lateral abdominal



dashes which, with the medial one, give the characteristic *tripunctatum* appearance to members of the complex. Small individuals also have relatively large compound eyes, and in the smaller males the eyes more nearly approximate each other dorsally than in the larger individuals.

*Nymph.*—Similar to *femoratum*; the head is not emarginate on anterior margin, but may have three small, pale spots on fore edge; abdominal tergal pattern (fig. 30) never obscured; abdominal sternites 2-8 (fig. 31) with a lateral pair of brown spots on each segment; sternite 1 lacks the brown spots and sternite 9 has two pairs, an anterior and a posterior pair. These spots increase in size progressively from segments 2-7; those on the 8th sternite are slightly smaller than on the 7th; the anterior pair on the 9th is much smaller while the posterior pair is the largest of all. A small median dash may be present between this last pair.

*Type.*—Milwaukee Co., Wis., 22.VII.1908, S. Graenicher collector, in Mus. Comp. Zool.

*Known distribution.*—Ontario and Quebec, New York, Wisconsin, Minnesota, Ohio, Michigan, Indiana, Illinois, Pennsylvania, Missouri, Oklahoma, Kansas, Texas, Alabama, Georgia, and North Carolina.

*Remarks.*—This is one of the most variable subspecies of the genus insofar as coloration of the imago is concerned. The nymph, however, seems rather constant. It lives in the quieter waters of streams of various sizes and seems particularly well suited to the lakes of the glaciated areas. The three dark dashes on the abdomen, the crowding of the cross veins in the first three areas of the bullar region, and the lack of the dark cloud in the apex of the hind wing will separate the subspecies from all others. *S. birdi* Traver represents a dark *tripunctatum*. It is interesting to note that *S. femoratum tripunctatum* has not been found in southeastern New York or in those states that lie east of the Hudson River.

### ***Stenonema femoratum scitulum* Traver**

*Stenonema scitulum* Traver, Biol. Mayflies, p. 330, 1935.

*Subspecific Characteristics; Male imago.*—Differs from *tripunctatum* only in the small size and the presence of the brown cloud in the apex of the metathoracic wing; the compound eyes appear relatively large and nearly contiguous; length of fore wing, 8-10 mm.

*Female imago.*—Similar to male except for dimorphic differences; length of fore wing, 9-11 mm.

*Variations in imagoes.*—The color variation of this subspecies parallels that of *tripunctatum* except that no individual is as dark as the extremes of *tripunctatum*. The amount of apical infuscation varies considerably but is always present in both sexes.

*Nymph.*—Unknown; unquestionably close to *tripunctatum*.

*Type.*—Latimer Co., Oklahoma, 10.VI.31 (R. D. Bird), No. 1343.1 in Cornell Univ. Coll.

*Known distribution.*—Kansas, Oklahoma, Missouri, Illinois and Indiana.

*Remarks.*—Except for the dark tip of the hind wing, individuals in this subspecies would invariably be considered as small specimens of *tripunctatum*. In fact, individuals that have lost the hind wings cannot

be placed with certainty, although the small size is a dubious criterion. The comparatively large size of the male's compound eyes is not reliable since small individuals of *tripunctatum* also show this character. Likewise I have specimens of *tripunctatum* that occasionally display a small amount of infuscation in the apex of the hind wing.

Information now available indicates that *scitulum* nymphs are stream dwellers that emerge from June to September. Probably it commences its emergence later than does *tripunctatum* and continues later in the season, but there is a considerable period when they are both emerging at the same time.

### ***Stenonema interpunctatum* complex**

This complex consists of the species *gildersleevei*, *carolina* and *interpunctatum*. *S. gildersleevei* and *carolina* occupy relatively small geographical areas, i. e., the uplands and hill country of the eastern United States. Individuals of *gildersleevei* and *carolina* are relatively uniform and, upon the basis of present information, these species display no subspeciation. *S. interpunctatum* in contrast occupies a wide area and is found in lakes and streams, both lowland and upland, and the individuals are highly variable. Numerous species have been described in the past but, employing numerous specimens as a basis, I have synonymized a number of these species and reduced the remainder to subspecific status. Due to a paucity of morphological characters, we are forced to rely mainly upon such characters as color for subspecific determinations. Genitalic as well as distinct, clear-cut color differences are available, however, for the separation of the three species. Within *interpunctatum*, degree of difference rather than absolute difference is the main delimiting criterion. No experimental evidence exists to indicate how much or how little coloration of the imaginal individuals of this genus is independent of the environment in which the nymph develops. Circumstantial evidence (Spieth, 1938) indicates, and such evidence is constantly accumulating, that the environment may play a part in determining the *degree* of coloration of the adult.

The complex is characterized as follows:

*Egg*.—Ellipsoid without chorionic markings but with a long terminal thread at each end which is coiled when oviposited, but which Morgan (1913) says uncoils in the water. In addition, there are several other shorter and finer chorionic threads.

*Nymph*.—Slender, appearing more delicate than the robust, chunky *femoratum* nymphs; galear portion of maxilla with nine or ten heavy setae that are comb-like on their distal ends; 2nd segment of maxillary palpus as in fig. 14; dorsal lamellae of gills 1-6 (fig. 22) pointed distally; tracheal distribution of these lamellae reminiscent of that found in *Heptagenia maculipennis*; 7th gill (fig. 16) sparsely setose, often with as many as three tracheal branches; no spines (figs. 19 and 29) on postero-lateral corners of abdominal segments 1-6, very small spines on 7, and small slender spines, equal in length, on 8 and 9.

*Imago*.—Slender stenonemids that range in color from piceous brown with yellow tones to pale translucent whitish yellow, tinged with greenish; cross veins in the proximal regions of the costal and radial areas aslant, thickened and margined; in the bulla region of radial area

often a black dash connects the cross veins; genitalia (figs. 2, 4 and 6) not boot-shaped and, except for *carolina*, with a group of spines on lateral margin.

*Remarks.*—This complex, on the basis of the nymphal mouth parts, especially the maxillae, the nymphal gills, both shape and tracheation, the spination of the nymphal abdomen, the shape of the adult styliger plated and the penes, is more closely related to *Heptagenia* and *Ecdyonurus* than is any other part of *Stenonema*.

### *Stenonema carolina* Banks

*Heptagenia carolina* Banks, Proc. Acad. Nat. Sci. Phila. 66: 616, 1914.

*Ecdyonurus carolina* Banks. McDunnough, Trans. Roy. Soc. Canada 19: 207, 222, 1925.

*Stenonema carolina* Banks. Traver, Jour. Elisha Mitch. Sci. Soc. 48 (2): 197, 1933. Biol. Mayflies, p. 309, 1935. Jour. Elisha Mitch. Sci. Soc. 53 (1): 38, 1937.

*Specific Characteristics; Male imago.*—General color gallstone yellow, faintly tinged with green; no black marking on face; eyes small and relatively widely separated; vertex tinged with orange; prothorax with slender oblique black streak on each side; meso- and metathorax unmarked; thoracic femora with medial and distal black dashes, but medial dash is lacking on the metathoracic femur; first tarsal joint of fore leg slightly less than one-half of second; radial cross veins proximal to the bulla and costal cross veins proximal to stigmal area aslant and margined with black; radial cross veins in bullar area rather heavily margined, but only rarely fused to form a dash; wing membrane of stigmal area and adjacent wing tip tinged with tawny; marginal veinlets of wing tips not thickened. Posterior margin of abdominal segments black with pigmentation heavier on tergites than on sternites; genitalia as in fig. 4; forceps pale fuscous; cerci pale fuscous with joinings very narrowly black; fore wing length, 8–12 mm.

*Female imago.*—Similar to male except for dimorphic differences; fore wing length, 11–14 mm.

*Variations in imagoes.*—Considerable size difference (8–12 mm. wing length) exists in the males of this species. The difference appears to be seasonal since the small individuals were collected late in the summer (August). Early season specimens from New York are darker than normal due to a brownish coloration on the dorsal surface, which somewhat obscures the greenish tinge. Otherwise, the individuals of the species seem remarkably constant.

*Holotype.*—Black Mt., N. C., May, 1913 (north fork Swannanoa Riv.). Mus. Comp. Zool.

*Known distribution.*—The species is found in the upland waters of eastern North America. *S. carolina* has been reported from New York, West Virginia, Tennessee, North Carolina, and South Carolina. In Canada it has been taken at Covey Hill and Knowlton, Quebec, which are located on northern outliers of the Appalachian and Green Mountains. It is absent from the lowlands of the St. Lawrence River drainage. Eventually it will probably be reported, in addition to the above areas, from the uplands of Alabama, Georgia, Virginia, Pennsylvania, Connecticut, Massachusetts, Vermont, and possibly New Hampshire.

*Remarks.*—Imagoes of *carolina* can be distinguished from all other species and subspecies of the *interpunctatum* complex by the male penes, the clear greenish-yellow coloration, and the almost total lack of black markings. The nymphs, on the basis of present information, can be identified by the lack of the continuous dorsal, longitudinal, light abdominal stripes. Since the imagoes lack stigmal spots there is no indication of these showing through the nymphal cuticle as is the case in *frontale*. Living in a relatively small area that is ecologically rather uniform, this species exhibits the least variation of any of the *interpunctatum* complex.

### ***Stenonema gildersleevei* Traver**

*Stenonema gildersleevei* Traver, Biol. Mayflies, p. 315, fig. 92, 1935.

*Specific Characteristics; Male imago.*—General color yellow but darker dorsally, especially on abdomen; heavy black mark on clypeus under each antenna; black mark on carina at similar level, sometimes forming with lateral dashes a continuous transverse band; eyes normal for *interpunctatum* complex; vertex reddish-brown; prothorax with oblique black streaks; meso- and metathoracic scutella piceous; pterothoracic pleura unmarked except for a slight darkening before the mesothoracic coxae; pterosternum unmarked; all femora with medial and distal piceous areas; first tarsal joint of fore leg usually one-half of second; radial and costal cross veins proximal to bulla only slightly aslant, sometimes faintly thickened, but never margined; bullar area usually with 1-2 radial cross veins which are lightly margined but never joined to form dash; costal and subcostal membrane tinged with yellowish-green; veinlets of fore wing tip faintly thickened. Abdomen dorsally with yellow background; tergites heavily infuscated with piceous, especially along median line and posterior margins; as this infuscation fades out laterally, the combination with the yellow ground color creates a brownish color; the anteriolateral corners of the tergites lack the piceous infuscation and therefore appear yellow. Small submedian lighter areas are usually found in the deeply infuscated dorsal region. The posterior tergites are also much less infuscated than are the anterior ones. Sternites yellow with piceous infuscation along the median line, heaviest just behind the anterior margins of each sternite; ninth sternite usually tinged with red; genitalia (fig. 6) with penes longer than in *interpunctatum* and with reduced distolateral expansion; length of fore wing, 10.5-12 mm.

*Female imago.*—Similar to male except for dimorphic differences; length of fore wing, 12-15 mm.

*Variations in imagoes.*—Size variations in the species are small. The length of the male first fore tarsal joint when compared to the second is somewhat variable. Usually it is about one-half the length of the second, but in some individuals it is less than one-half and in others it is greater than half the length of the second. Thus measurements of 19 male fore legs show the ratio of the second tarsal/first tarsal to range from a minimum of 1.71 to a maximum of 2.30. Statistical analysis of this sample gives an arithmetical mean of 1.99 with a standard deviation of 0.17 and a V of 8.47. The estimated range for

this ratio is 1.48-2.50. The amount of melanistic pigmentation, especially of the abdomen, varies considerably. The abdominal tergites of some specimens are intensely and broadly blackened. These individuals have a complete frontoclypeal band, have the abdominal sternites considerably darkened and show no signs of abdominal stigmal spots due to the covering effect of the dorsal coloration. In others the black pigment of the abdominal tergites is much reduced and mainly concentrated near the medial line. In such specimens the clypeus has a dash under each antennae and a blackish mark on the carina, while the abdominal sternites may almost lack any dark colors and stigmal spots are visible, especially on segments 2-6.

*Nymph*.—Head without anterior light marginal area; abdomen with a narrow transverse piceous stripe on terminal edge of each tergite; medial part of tergites, especially the anterior ones, infuscated; a pair of submedial, light areas on each tergite, these tending to be oval and not linear, small on the anterior segments but longer posteriorly. These light areas give the abdomen the lined appearance typical of the *interpunctatum* complex, which is less evident than in *canadense* but more evident than in *carolina*. Sternites immaculate except for dark lateral dashes on segments 7-10.

*Holotype*.—Kirtland, O., August 31, 1930 (spring-fed stream of Gildersleeve Mt.), No. 1337.1 in Cornell Univ. Coll.

*Known distribution*.—The species has been collected in northern and southern New York and northeastern Ohio. The intensive collecting done by numerous Canadian entomologists has failed to discover any specimens of *gildersleevei* in Canada. It probably occupies a limited area in the northern Appalachians.

*Remarks*.—Imagoes of *gildersleevei* can be readily distinguished by the male genitalia, the concentration of black pigments on the medio-dorsal part of the abdomen, and the unmargined, almost vertical radial and costal cross veins. The yellowish ground color is also distinctive. Unquestionably it has been confused in the past with *canadense*. *S. canadense*, however, has the piceous pigments much more widely distributed, especially on the thorax, and the margined, slanting cross veins plus the usually present bullar dash are distinctive characters for its separation from *gildersleevei*.

The type of *gildersleevei* was reared from the mature nymph which was found in a cold spring-fed stream. This holotype, plus the allotype and 8 paratypes all from the same locality, emerged in late August and early September. Traver also reared specimens at the same time from a nearby locality which she described as *ohioense*. She indicates (1935, pp. 316 and 322) that *ohioense* is rather closely related to *gildersleevei*. Study of the type of *ohioense* shows it to be a synonym of *canadense* and not closely related to *gildersleevei*.

### *Stenonema interpunctatum* Say

This species consists of four subspecies, *interpunctatum* Say, *canadense* Walker, *frontale* Banks, and *heterotarsale* McD. *Stenonema candidum* Trav., *conjunctum* Trav., *major* Trav., *pallidum* Trav., and *proximum* Trav. have been described as species of the *interpunctatum* complex, but are synonyms of the four subspecies listed above. Traver

(Biol. of Mayflies, p. 316) synonymized *Stenonema affine* Traver with *heterotarsale* McD. Study of numerous individuals from a large number of localities, including all the types except that of *interpunctatum* s. str. which is nonexistent, has made it possible to modify the taxonomy of this complex.

Geographically *interpunctatum* is the most widespread species of *Stenonema* and apparently is found throughout the entire range of the genus. The nymph lives in streams, or in bodies of water where stream conditions are simulated, but it can not tolerate swift currents. It seems to be more hardy and adaptable than are most species of the genus.

The emerging imagoes become smaller in size and lighter in color as the season progresses, thus paralleling the condition found in *S. tripunctatum*. This phenomenon of size and pigment reduction as the season progresses is apparent only in areas which are ecologically uniform and in which only one subspecies is present. In areas where subspecies overlap and intergrade, the resultant mixed population may appear not to follow this pattern, especially so far as color is concerned. The picture is further complicated in such areas by seasonal and ecological isolation. Thus Ide (1935, p. 46) found that *heterotarsale* and *canadense*, both of which live in the Mad River, Ontario, overlap only slightly in their ecological and seasonal occurrence; *canadense* emerges earlier in the season and lives further up-stream, i. e., in colder water. Only at the upper range of *heterotarsale* and the lower limit of *canadense* do they overlap both in space and time. In regions where a large warm stream has numerous small spring-fed tributaries, it is to be expected that series can be collected which will show both subspecies to be plentiful at the same time, i. e., late emergents of the early form from the cool tributaries and early emergents of the late form from the warm stream.

Adequate sampling from such an area will always bring to light numerous intergrades. Sometimes the collection is complex, e. g., a series that I collected July 1 from the Lachine Rapids on the St. Lawrence River contains typical specimens of *canadense*, *frontale*, and *heterotarsale* and all intergrades between them; one specimen, except for the long first tarsal joint, can not be told from typical specimens of *interpunctatum* from southern Indiana.

The characters employed to separate these subspecies of *interpunctatum* deserve a word of comment. In the past, genitalic differences have been used but careful study of a series of genitalic preparations convince me that within the species any differences are either individual or caused by the technique used in the preparation of the specimen. Likewise, the length of the first tarsal segment has been used and is of considerable value but is highly variable. The ratio derived by dividing the length of the second segment of the male fore tarsus by the length of the first segment provides a character that can be handled statistically to good advantage. Likewise the ratio derived from the fore wing length divided by the first segment of the male fore tarsus is useful. Due to the paucity of such characters, coloration has been commonly utilized, especially the following: (1) the amount of black pigmentation on (a) the clypeus, (b) the prothorax, (c) the pterothoracic pleura, (d) the abdomen, especially the dorsum, and (f) the

cercal joinings; (2) the presence or absence of stigmal spots on the abdominal tergites, and (3) the bullar streak of the fore wings. All of these characters exhibit great variability—seasonally as well as individually. Size parallels coloration in variability. On the basis of present information, it can be said that in any given locality the early seasonal emergents are larger and darker than those that emerge later. Size and coloration thus display both seasonal and individual variation, and the latter type is of considerable magnitude.

Those species listed above which have been synonymized all appear to be color variants of the four subspecies that have been retained. The four subspecies, comprising the species, are distributed as follows: *interpunctatum s. str.* is found mainly in the lower and middle Mississippi and the Ohio River drainages; *canadense* in eastern Canada, in the northern tier of eastern and mid-western states, and extending southward along the eastern highlands; *frontale* in the eastern part of the United States, extending westward along the shores of the eastern Great Lakes. Finally, *heterotarsale* is centered around Lake Erie and Lake Ontario and extends westward into northern Indiana and Illinois.

### ***Stenonema interpunctatum interpunctatum* Say**

*Baetis interpunctata* Say, Jour. Acad. Nat. Sci. Phila. 8: 41, 1839. Complete Writings of Thomas Say, 2: 411.

[nec] *Heptagenia interpunctata* Say. Eaton, Mono. Rec. Ephem., pt. 4: 267, 1885. Clemens, Canad. Ent., 56: 17, 1924.

*Ecdyonurus interpunctatus* Say. McDunnough, Canad. Ent., 65: 42-43, 1933.

*Stenonema interpunctatum* Say. Traver, Biol. Mayflies, pp. 317-318, 1935.

*Stenonema affine* Traver, J. Elisha Mitchell Sci. Soc. 48: 184, 1933.

*Stenonema pallidum* Traver, Biol. Mayflies, pp. 323-324, 1935.

*Subspecific Characteristics; Male imago.*—General color chrome yellow, faintly tinged with green; black dot on clypeus under each antenna; eyes normal in size; vertex reddish-brown; prothorax with oblique black streak on each side; pterothorax unmarked except for mesonotum which is normally pale chestnut; metathoracic femur with distal dark band but normally lacking medial; second tarsal/first tarsal ratio from 1.8 to 3.5 with about 2.6 as the most common; radial cross veins proximal to the bulla and costal cross veins proximal to the stigmal area aslant and margined; a black dash in radial area at level of bulla, often connecting two or more cross veins; wing membrane of costal and subcostal areas yellowish, with stigmal area and wing tip slightly darker; marginal veinlets of fore wing tip thickened; wing length varying from 5.8 to 10.1 mm. with about 8 mm. as the most common; abdominal tergites 1-8 pale translucent yellow; distal part of 8 and all of 9 and 10 ferruginous; all tergites with narrow piceous posterior margin; sternites unmarked; genitalia (fig. 2) cream colored; cerci pale with joinings faintly darkened.

*Female imago.*—Similar to male except for dimorphic differences.

*Variations in imagoes.*—The description given above is from a typical specimen collected at New Harmony, Indiana. Individuals that emerge in the early spring tend to be large and somewhat darkened due to the dorsum of the abdomen being infuscated with blackish while the metathoracic leg may have a dark medial band. Some individuals, irrespective of emergence time, show faint stigmal spots such as are

normally found in *frontale*. Measurement of 20 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 2.15 to 3.5 with a mean of 2.63, a standard deviation of 0.28 and a coefficient of variation (v) of 10.65. The standard error of the mean is  $\pm .063$ . The distribution of the sample is positively skewed. The estimated range is 1.79 to 3.47. The forewing of 20 specimens gave an observed range of 6.6 to 9.05 mm. with a mean of 7.98 mm., a standard deviation of 0.72 and a coefficient of variation of 9.02; the standard error of the mean is  $\pm .16$ . The estimated range of the wing is 5.82–10.14 mm. The wing length, unlike the tarsal ratio, is influenced by seasonal variation.

*Known distribution*.—Mississippi River drainage, especially the middle and lower parts, and the Ohio River drainage.

*Remarks*.—The subspecies can be identified by the general yellow coloration, the lack of dark markings on the pterothoracic pleura, and the typically short first segment of the fore tarsus. As mentioned above, Say's description fits material that is possibly topotypical. Large specimens of *heterotarsale* may be confused easily with this subspecies and we may expect to find specimens of *heterotarsale* with fore wings that equal or exceed the longest wings of *interpunctatum*. The male second/first tarsal ratio and the dependent wing/tarsal ratio seem to be good criteria and the only fairly dependable ones available for separating some individuals of *heterotarsale* from *interpunctatum*. It is possible that specimens from the southeastern United States which have been considered as belonging to *interpunctatum* may belong to *frontale*. This also applies to Traver's *pallidum*. The reasons for such possible deductions are discussed below in the full discussion. In any instance, more specimens from such areas will be needed before a final decision can be drawn.

### ***Stenonema interpunctatum canadense* Wlk.**

*Baetis canadensis* Walker, List Neuropt. Ins. Brit. Mus., pt. 3: 569, 1853.

*Ecdyurus canadensis* Walker. Eaton, Revisional Mono. Rec. Ephemeridae, part 4: 278, 1885.

*Ileptagenia canadensis* Walker. Clemens, Canad. Ent. 45: 258, 1913.

*Ecdyonurus canadensis* Walker. McDunnough, Trans. Royal Soc. Canad., 19 (sec. 5): 222, 1925.

*Stenonema canadense* Walker. Traver, Biol. Mayflies, p. 307, 1935. Ide, Canad. Jour. Res., 12: 447–457, figs., 1935. Spieth, Ann. Ent. Soc. Amer., 33: 333, 1940.

*Stenonema ohioense* Traver, Biol. of Mayflies, p. 322, 1935.

*Subspecific Characteristics; Male imago*.—General coloration typically yellowish with enormous amount of piceous color, especially dorsally; superficially much like *S. gildersleevei* Trav. Differs from *interpunctatum* mainly in the increased amount of black infuscation. Clypeus with horizontal piceous band; eyes normal; vertex as in *interpunctatum*; prothorax with oblique bands and lateral markings; pterothorax with oblique, piceous pleural streaks from each wing base; mesonotum darker than in *interpunctatum* and with scutellum piceous; metascutellum dark; metathoracic femur with both distal and medial bands; first tarsal joint about as in *interpunctatum*; the second tarsal/first tarsal ratio varying from 1.6 to 3.1 with 2.3 as the most common; wings marked as in *interpunctatum* but more intensely; bullar area usually ferruginous.



Dorsum of abdomen broadly piceous with scimitar-shaped, paired, subdorsal pale streaks; areas that are not infuscated with piceous translucent to transparent and not colored with yellow as in *gildersleevei*; wing length varying from 6.6 to 12.1 mm. with about 9.3 mm. as the most common; sternites hyaline or semihyaline but often tinged with black; genitalia as in *interpunctatum*; cerci pale with dark joinings.

*Female imago*.—Similar to male except for dimorphic differences.

*Variations in imagoes*.—A large amount of variation exists in the amount of black infuscation which characterizes the subspecies. This can be attributed to three causes, but which is responsible in any particular individual it is impossible to say. These causes are: (1) individual variation; (2) seasonal variation, late seasonal emergents usually being much lighter in color; (3) interbreeding with lighter colored subspecies. The lightly infuscated individuals invariably display robust stigmal spots on the abdominal tergites. Apparently these are obfuscated in the darker individuals by the dark coloration of the tergites.

Measurement of 43 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 2.00 to 3.00 with a mean of 2.34, a standard deviation of 0.257 and a V of 11.0. The standard error of the mean is  $\pm .039$ . The distribution of the sample is positively skewed. The estimated range is 1.57 to 3.10. The fore wing length of 26 male individuals ranges from 8.28 to 9.95 mm. with a mean of 8.90, a standard deviation of 0.389 and a V of 4.34. The standard error of the mean is  $\pm .076$  and the estimated range is from 7.8–10.13 mm. Sometimes individuals are found that agree with *canadense* except for long first tarsal joints. These apparently are intergrades with *heterotarsale*.

*Nymph*.—Head without anterior light marginal area; abdomen (fig. 29) darker than thorax; four longitudinal abdominal streaks, two submedianly and the others near lateral margin; future stigmal dots of imago often visible; abdominal sternite with two light brown lateral streaks on white background; ninth sternite with lateral and posterior margins infused with same color.

*Holotype*.—Canada, in Walker Coll. in Brit. Mus. (Nat. Hist.). Nymph associated with imago by Clemens, 1913, at Go-Home-Bay, Georgian Bay, Ontario, Canada.

*Known distribution*.—Quebec, Ontario, Minnesota, Michigan, Illinois, Indiana, Ohio, New York, Connecticut, New Jersey, West Virginia, Tennessee, and North Carolina.

*Remarks*.—Clemens (1924) first indicated that this is a subspecies of *interpunctatum*. Superficially it is nearer to *S. gildersleevei* than is any other species of the complex. The genitalia, the color pattern, and the fore wing pattern are reliable means of separating the two. Typical specimens can not be confused with any of the other subspecies of *interpunctatum*. Lightly infuscated individuals, regardless of the cause, are extremely difficult to separate from *frontale*, or, if they also lack the stigmal spots, from *interpunctatum* and *heterotarsale*. Clemens (1913) reared and adequately described the nymph. It is typical of the *interpunctatum* complex. Upon the basis of my present information, I can not separate it from nymphs which I think belong to *interpunctatum*.

**Stenonema interpunctatum frontale Banks**

*Heptagenia frontalis* Banks, Canad. Ent., 42: 199, 1910. Clemens, Canad. Ent., 45: 259, fig. nymph, 1913.

*Ecdyonurus frontalis* Banks. McDunnough, Canad. Ent., 62: 61, 1930. Canad. Ent., 65: 43, 1933.

*Stenonema frontale* Banks. Traver, Biol. Mayflies, p. 312, fig., 1935.

*Stenonema candidum* Traver, Biol. Mayflies, p. 308, 1935.

*Stenonema conjunctum* Traver, Biol. Mayflies, pp. 309-310, 1935.

*Stenonema majus* Traver, Biol. Mayflies, p. 320, 1935.

*Stenonema proximum* Traver, Biol. Mayflies, p. 325, 1935.

*Subspecific Characteristics; Male imago*.—General color chrome yellow, faintly tinged with green; black dash on clypeus under each antennac and a spot on carina at the same level; eyes normal; vertex as in *interpunctatum*; prothorax with oblique band and black dot on posterolateral corner; pterothorax with oblique piceous pleural streaks from each wing base; mesonotum darker than in *interpunctatum* but lighter than in *canadense*; meso- and metascutella yellow; metathoracic femur with medial and distal bands; second tarsal/first tarsal ratio more variable than in *interpunctatum* or *canadense*, ranging from 1.2 to 3.5 with approximately 2.3 as the most common; wings as in *interpunctatum* except bullar dash is often restricted and does not join several cross veins; the wing length varies from 6.6-12.1 mm. with about 9.38 mm. as the most common. Abdomen as in *interpunctatum* except for heavier posterior black margins and the presence of prominent robust stigmal spots; genitalia as in *interpunctatum*; cercal joining darker than in *interpunctatum*.

*Female imago*—Similar to male except for dimorphic differences.

*Variations in imagoes*.—Normal variation appears to be large and, especially where *frontale* intergrades with populations of *canadense* and *heterotarsale*, an extremely variable population is formed. Measurement of 56 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 1.6-3.2, with a mean of 2.37, a standard deviation of 0.39 and a V of 16.60. The standard error of the mean is  $\pm .052$ . The distribution of the sample approaches that of normal but indicates considerable variability for this character of the subspecies. The estimated range is from 1.19-3.55. The fore wing of 42 males varies from 6.77-11.2 mm., with a mean of 9.38 mm. and a standard deviation of 0.92 and a V of 9.7. The standard error of the mean is  $\pm .16$  and the estimated range is from 6.62-12.14 mm.

*Nymph*.—Often with a pale spot on anteromedial margin of head; dorsal abdominal color pattern (fig. 19) distinctive due to the reduction of the longitudinal light streaks that are present on the nymphal abdomens of the other subspecies. Sternites as in fig. 28.

*Holotype*.—Middlesex Falls, Mass., August. In Mus. Comp. Zool. Coll.

*Known distribution*.—Nova Scotia, Quebec, Ontario, New Hampshire, Vermont, Massachusetts, New York, and Ohio.

*Remarks*.—Typical specimens, either as nymphs or imagoes, of this subspecies are easily identified, the nymphs by the distinctive dorsal abdominal pattern and the adults by a combination of stigmal spots, thoracic coloration, and wing pattern. All degrees of intergradation exist between *frontale* and *canadense*, *frontale* and *heterotarsale*, and

*frontale* and *interpunctatum* in both the nymphal and the imaginal stages. The abdominal pattern of the nymph figured by Traver (1935, Pl. 24) is not typical for *frontale* and probably indicates *canadense* hybridization. The genitalic differences between *canadense* and *frontale* as given by Traver (1935, fig. 91) apparently are individual rather than specific or subspecific. *S. candidum* Trav., *conjunctum* Trav., *majus* Trav., and *proximum* Trav. are not quite typical examples of *frontale*. Actually, study of the types indicates that they represent intergrades (or environmental variants) of *frontale* with other subspecies. Since they are more nearly like *frontale*, I have synonymized them with it. *S. candidum* deserves mention in that the differences, given by Traver (1935), are restricted to the genitalia. According to the original description (Traver, 1935, p. 308) only three individuals of *candidum*, two males and one female, were known. At Cornell I found the male holotype from which the genitalia had been detached. Except for the penes it agreed in all respects with *frontale*. The mounted genitalia which merely bore the same data as the type, but no number or other identifying mark that would connect it with the holotype, agree with Traver's figure and certainly resemble those of *S. carolina*. Unfortunately the male paratype, except for a mounted wing and the nymphal skin, has been lost. These remaining parts bear facies of *S. frontale*. Perhaps one of two things has occurred: (1) either the genitalia attributed to the holotype are those of a specimen of *carolina*, or (2) the holotype was an aberration lacking the lateral genitalic spines. In any instance, I consider it to be a synonym of *frontale*.

#### *Stenonema interpunctatum heterotarsale* McD.

*Ecdyonurus heterotarsale* McDunnough, Canad. Ent., 65: 42, 1933.

*Stenonema heterotarsale* McDunnough. Traver, Biol. Mayflies, p. 316, 1935.

*Subspecific Characteristics; Male imago*.—General coloration as in *interpunctatum*. Differs from *interpunctatum* in the lack of black markings and the greater length of the first fore tarsal joint. Clypeus unmarked; head otherwise as in *interpunctatum*; prothorax unmarked; pterothorax without black marks; mesonotum, metanotum, wings, and markings on legs as in *interpunctatum*. First segment of fore tarsus long; the second tarsal/first tarsal ratio ranging from 1.0–2.1 with 1.6 as the most common. Wing length varies from 5.0–10.2 mm. with about 7.5 mm. as the most common. Abdomen, including genitalia and cerci, as in *interpunctatum*.

*Female imago*.—Similar to male except for usual dimorphic differences.

*Variations in imagoes*.—Typical specimens as described are not very numerous. Only the size and long first tarsal joint seem relatively constant. Many individuals, although much lighter than those of *interpunctatum*, do have some dark markings. This is especially true of the clypeal marks, the oblique prothoracic marks, and stigmal marks. Measurement of 44 male fore legs gave an observed range for the second tarsal/first tarsal ratio of 1.15–1.95 with a mean of 1.57, a standard deviation of 0.18 and a V of 11.4. The standard error of the mean is  $\pm .026$ . The distribution of the sample approaches normal. The estimated range for this ratio is 1.03–2.10. The fore wing length of 22

individuals ranges from 6.18–9.22 mm. with a standard deviation of 0.87, a *V* of 11.57, and a mean of 7.59. The standard error of the mean is  $\pm .187$  and the estimated range is 4.95–10.23 mm. Thus, both wing length and tarsal ratios may be expected broadly to overlap those of the other subspecies. Note that seasonal emergence plays a large role in wing length.

*Nymph*.—Undescribed, but probably close to *interpunctatum*.

*Holotype*.—Ottawa Golf Club, Quebec, 2.VII.24, No. 3527 Canadian Nat. Coll., Ottawa.

*Known distribution*.—Northern Ohio, northern Indiana, northern Illinois, Michigan, northwestern New York, Ontario, southwestern Quebec. This subspecies seems to be centered around Lake Erie and Lake Ontario.

*Remarks*.—*S. affine* Traver (1933) is probably a synonym of *interpunctatum* s. str. rather than of *heterotarsale* as she suggested (Traver, 1935). *S. heterotarsale* emerges on the average later in the summer than does any of the other subspecies of *interpunctatum*. It is possible that those specimens that have been placed in *heterotarsale* are merely late season individuals of *frontale*. Certainly size and fore tarsal segmental length are highly variable, and the casual student of ephemeroids will find *heterotarsale* a rather exasperating subspecies to delimit.

#### DISCUSSION AND STATISTICS OF THE STENONEMA INTERPUNCTATUM COMPLEX

Study of all existing types and various collections (i. e., Cornell University, Museum of Comparative Zoology, Canadian National Collection, University of Michigan, Illinois Natural History Survey, American Museum of Natural History, plus my own collection) show the presently accepted species picture of the *interpunctatum* complex to be questionable. *Stenonema carolina* Banks and *S. gildersleevei* Traver are distinct species that can be definitely delimited and identified. The remaining nine species of the complex present a complicated and irritating problem. Comparison of numerous individuals with the holotypes shows that some specimens correspond closely with the types, but many individuals are clearly intermediate. Study of the available paratypes shows that many of them vary considerably from the holotypes. When confronted with a large series, especially from the areas around the Great Lakes, more "intermediate" than "typical" specimens are invariably found. All evidence indicates that some of the existing names need to be synonymized and the remainder reduced to sub-specific status.

Such a revision seems rather drastic and I wished to study all available evidence before reaching a final decision. The following procedure was therefore undertaken. Utilizing my own collections and those of the American Museum of Natural History, all specimens of the complex, other than those of *S. carolina* and *S. gildersleevei*, were sorted according to geographical distribution and date of collection. Utilizing pinned adult males, those specimens that were relatively perfect were given individual numbers and then the following data were recorded in tabular form for each specimen: (a) length of first and second tarsal seg-

ments of fore leg, (b) coloration of thorax, (c) coloration of abdomen, (d) presence or absence of abdominal stigmal markings, (e) length of fore and hind wings, and (f) number of x-veins involved in the bullar dash or spot of the fore wing. For the coloration records, four arbitrary grades of ascending order of intensity, 0, 1, 2, and 3, were established. A low power binocular microscope was used for magnification. Tarsal segment measurements were made with 1.7x oculars and 2.3x objectives. Wing length measurements and all other data were recorded with 12.5x oculars and 1.0x objectives. An artificial light source (microscope lamp with "daylight" glass filter) was used to illuminate the specimens. Specimens preserved in alcohol were not used, although many were available, because the colors, especially those other than the melanins, fade rather rapidly and also because the male fore legs so often become detached. The information from series of individuals collected at the same place and time was then tabulated. Within the limits of availability, series were studied from the entire geographical range of the complex. Later, after these data had been studied, individual specimens or small series from what appeared to be critical areas were also studied and measured. In all, two hundred and one (201) specimens were so treated. Twelve (12) of these specimens were individuals of *S. gildersleevei* which were measured and utilized for comparative statistics.

The data thus assembled were subjected to statistical analysis. Not all of the characters could be subjected to the simple statistics employed, but they could be used in connection with those characters that were so analyzed. The arithmetic mean ( $M$ ), the standard deviation ( $\sigma$ ) and the coefficient of variation ( $V$ ) were determined for the second/first tarsal segment ratio, the fore wing length, and the wing length/first tarsal segment ratio.<sup>1, 2</sup> The two ratios gave pure numbers that are independent of the absolute size of the individuals. This is important because stenonemids vary in size not only individually but also seasonally. In utilizing the data the assumption has been made that size, variation, both individual and seasonal, exert no effect on the ratios derived from the tarsal and wing measurements.

Since the coefficient of variation is a measure of relative variability, more weight has been given to it than to the absolute measurements. This will become more evident in the specific discussions below.

Note also that unless special mention is given whenever a series is considered, all the specimens taken at that particular place at that time have been utilized. Some individuals, however, lack legs (due to breakage subsequent to collection) while others possess wings that are unmeasurable, and therefore the total for the two series may vary for the different measurements.

Having determined the  $M$  and  $\sigma$  of each sample, an estimate was then made of the parameter of the particular population from which the

<sup>1</sup>Since the cross hatched measuring scale was placed below the lens system of the ocular, by multiplying the wing length by 2.3 the resultant figure was of the same size units as those of the tarsal segments.

<sup>2</sup>The computations were accomplished with the aid of FORM FOR MEAN and STANDARD DEVIATION by Tryon and Searle, 1941, based on 1935 Form by R. C. and C. McC. Tryon.

sample was drawn. This was done by adding or subtracting three standard deviations from the mean (Tables I, II, and III). Finally, after the data had been analyzed and conclusions reached, a series of individuals typical for each of the four subspecies retained was selected and the statistics assembled. These series were treated similarly to the geographical series and will give at least the author's conception of the various subspecies which he considers valid.

A series of specimens collected 26.VI.38 from Alymer, Quebec, omitting one specimen of *heterotarsale*, agree in all respects with the accepted definition of *canadense*. The ratio derived by dividing the length of the second tarsal segment of the ♂ fore leg by the first tarsal segment of the same leg (hereafter called, for convenience, the second tarsal/first tarsal ratio) gives for this series (Table I) a maximum of 3.00, a minimum of 2.00, a M of 2.35 and a V of 11.72. A small series combined from specimens collected at Louisville, Ky., and New Harmony, Ind., displays (Table I) a maximum of 2.71, minimum of 2.29, M of 2.52, and a V of 5.81. These specimens are all typical *interpunctatum*. From Lexington, N. Y., 11.VI.38, all individuals which agree with the delimitation of *frontale* show (Table I) a maximum of 2.71, a minimum of 1.82, a M of 2.29 and a V of 10.25. In comparison, a series collected at the Lachine Rapids, Montreal, Que., 1.VII.38, shows individuals ranging in color from very pale yellow to examples almost as dark as the darkest *canadense*. The tarsal ratio for the series varies from 2.83 to 1.14, with a M of 1.79 and a V of 20.90. Clearly this sample is more variable than the preceding three. If these specimens are sorted on the basis of thoracic coloration and those with grade 0 and 1 are separated from the darker grade 2 (there are no grade 3 specimens), then (Table I) the variability especially of the grades 0 and 1 specimens drops sharply to a V of 8.64 but that of the grade 2 specimens actually increases (21.80). Removal of one individual (No. 21) which has a dark thorax but a long first tarsal segment is sufficient to drop the V of the grade 2 specimens to 17.75. Sorting the specimens on the basis of the abdominal coloration gives a similar but reversed picture. The grade 2 individuals possess a V of 14.0 while the grades 0 and 1 have a V of 20.8. Removal of one specimen (No. 3) which has a light colored abdomen and a short first tarsal segment reduces this V from 20.8 to 11.7. Thus, two distinct populations seem involved in the series. Removal of the two intergrades leaves a light colored, long first tarsal joint group with a V equal to those of the "pure" series and a dark colored, short first tarsal joint group of slightly greater variability. The long first tarsal joint, light colored specimens represent *heterotarsale*, while the short first, tarsal joint, dark colored specimens are *canadense*. Ide (1935) found that both *heterotarsale* and *canadense* live in the same Ontario stream (Mad River) but the latter at higher elevations and the two populations only slightly overlap in space and emergence time at this particular locality. Evidence from localities other than the Lachine Rapids contributes additional information that *heterotarsale* intergrades not only with *canadense* but also with *interpunctatum*. Thus, from Orillia, Ont., 7.VII.38, a series of thirteen (13) individuals vary from light (Grade 0) to dark (Grade 2) and one of the intermediate specimens (thorax, Grade 1; abdomen, Grade 2) has a

TABLE I  
RATIO OF  $\frac{\text{2ND TARSAL SEGMENT}}{\text{1ST TARSAL SEGMENT}}$  OF ♂ FORE LEG

PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1-VII-38	39	2.83	1.14	1.79	.376	20.90	2.92	0.66	All specimens
Same	21	2.00	1.43	1.64	.140	8.64	2.06	1.22	Spec. with Thorax 0 and 1
Same	18	2.83	1.14	1.95	.421	21.80	3.19	0.67	Spec. with Thorax 2
Same	16	2.83	1.60	1.98	.352	17.75	3.03	0.93	Spec. with Thorax 2; spec. 21 omitted
Same	29	2.83	1.14	1.65	.360	20.80	2.73	0.57	Spec. with Abdomen 0 and 1
Same	27	2.00	1.14	1.57	.185	11.70	2.12	1.02	Spec. with Abdomen 0 and 1; spec. 3 omitted
Same	10	2.57	1.75	2.01	.280	14.00	2.85	1.27	Spec. with Abdomen 2
Aylmer, Que., 26-VI-38	36	3.00	2.00	2.35	.278	11.72	3.18	1.52	All spec. have Abd. and Th. 2 or 3
Louisville, Ky., 22-VIII-40; New Harmony, Ind., 18-VI-36 and 30-V-40	14	2.71	2.29	2.52	.147	5.81	2.97	2.09	
Massey, Ont., 23-VI-36	10	1.87	1.60	1.66	.114	6.85	2.00	1.32	Th. and Abd. 0, but stigmal spots present
Sloatsburg, N. Y., 4-VI-38	20	3.25	1.67	2.53	.430	17.00	3.82	1.24	Th. and Abd. mostly 2; all with stigmal spots
Same	18	3.25	1.90	2.63	.332	12.60	3.62	1.63	Spec. 81 omitted; 81 has Th. and Abd. 0
Lexington, N. Y., 11-VI-38	20	2.71	1.82	2.29	.235	10.25	3.00	1.59	All spec. with stigmal spots
Bluffton, Ind., 20-VII-29	20	2.76	1.13	1.56	.416	26.70	2.80	0.32	
Same	15	1.66	1.13	1.35	.131	9.70	1.74	0.96	Spec. 136, 137, 151 omitted

PART II. Arrangement by Taxonomic Category

Category	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range	
		Max.	Min.				Max.	Min.
<i>canadense</i>	43	3.00	2.00	2.340	.257	11.00	3.11	1.57
<i>frontalis</i>	56	3.20	1.60	2.370	.394	16.60	3.55	1.10
<i>interpunctatum</i>	20	3.50	2.20	2.630	.280	10.65	3.47	1.79
<i>heterotarsale</i>	44	1.90	1.10	1.57	.178	11.30	2.10	1.03
<i>gildersleevei</i>	19	2.30	1.70	1.992	.169	8.50	2.50	1.48

tarsal ratio of 1.67. One light specimen had a tarsal ratio of 2.00 for one leg and 1.80 for the other leg, and is typically *interpunctatum* in facies. Most of this series were dark (*canadense*) in appearance. As the season progresses *heterotarsale* becomes more numerous vis a vis *canadense* and *interpunctatum*. A series of eight specimens from Elkhart, Ind. (St. Joseph's River), 3.V.40, shows two individuals to have long first tarsal joints as well as typical *heterotarsale* coloration. The other six are definitely of the *interpunctatum-canadense* type (they could be either dark *interpunctatum* or light *canadense*) and have short first tarsal joints. A collection of six individuals from the same locality and the same area of the St. Joseph's River, but made 14.VIII.40, consists of one *interpunctatum* and five typical *heterotarsale*. A collection of eleven specimens from Montreal, Que., 5.IX.34, consists mostly of *heterotarsale* type individuals, but two specimens are decidedly of the *canadense* type and one of these has a *canadense* ratio (2.00) and the other a *heterotarsale* ratio (1.33 and 1.38). Finally, the most mixed series available is from Bluffton, Ind., 20.VII.29. Eighteen specimens vary in coloration from typical *heterotarsale* and *interpunctatum* to light *canadense*. The tarsal ratio of these (Table I) gives a V of 26.7 with a mean of 1.56. However, if specimens No. 136 and No. 139 (both light *canadense*) and No. 151 (typical *interpunctatum*) are omitted, then the remaining individuals have a tarsal ratio M of 1.35 with a V of 9.70. These individuals have *heterotarsale* tarsal ratios and are mostly pale colored, but several of them are atypical in having black marks on the thorax and all possess stigmal spots on the abdomen. As noted under the description of *heterotarsale*, many individuals do have piceous markings and the commonest seems to be the presence of pterothoracic streaks and abdominal stigmal spots. All specimens of a small collection of *heterotarsale* from Massey, Ont., 23.VI.36, show definite stigmal spots. Another collection of *heterotarsale* from Proctor, Minn., 20.VII.36 (unmeasured), is similar to the Massey series.

From the data given above, it is possible now to summarize tentatively the relationships of *interpunctatum*, *canadense*, and *heterotarsale*. *S. interpunctatum interpunctatum* dwells in the Mississippi drainage. In the St. Lawrence drainage *canadense* is to be found. Both have their emergence peaks in the early summer; the early emergents are larger and darker than the seasonally later ones and this is especially true of the coloration of *canadense*. Where the two populations meet, they probably intergrade, but it is impossible to tell a light *canadense* from a dark *interpunctatum*. Also in the area around the Great Lakes, northern Indiana, Illinois, Ohio, New York, and along the St. Lawrence, there is a third population, *heterotarsale*, that certainly intergrades with *canadense* and probably with *interpunctatum*. This population reaches its peak of emergence at the end of the *canadense-interpunctatum* season. This has been noted by Ide on the Mad River, Ont., and shows clearly in the present study. Just what has kept and is keeping the *heterotarsale* population from completely amalgamating with the *canadense-interpunctatum* populations, it is impossible to say. Obviously there must be a definite survival value attached to each of the populations or they would quickly fuse into one variable one. Even so, there must be in nature an immense number of intergrading individuals. From present



TABLE II  
MALE FORE WING LENGTH  
PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1-VII-38	23	19.50	15.25	17.02	0.97	5.70	19.93	14.11	All specimens
Same	16	18.75	15.25	16.68	0.90	5.70	19.38	13.98	Spec. with 0 and 1 abdomens
Same	6	17.75	16.25	17.00	0.48	2.80	18.42	15.58	Spec. with 2 abdomens. N-1 for det. of V.
Aylmer, Que., 26-VI-38	23	20.50	18.00	19.27	0.62	3.21	21.13	17.41	All spec. have Abd. and Th. 2 or 3
Louisville, Ky., 22-VIII-40; New Harmony, Ind., 30-V-40 and 16-VI-36	9	19.50	15.75	18.07	1.36	7.51	22.13	14.02	
As above except Louisville specimens omitted	6	19.50	18.00	18.97	0.55	2.90	20.63	17.32	
Sloatsburg, N. Y., 4-VI-33	12	24.00	19.50	21.46	1.40	6.51	25.66	17.26	Spec. 81 included; high V due to 83 and 87
Lexington, N. Y., 11-VI-38	12	22.00	19.50	20.83	0.88	4.19	23.45	18.21	
Bluffton, Ind., 20-VII-29	14	17.00	13.50	15.03	0.96	6.26	17.91	12.15	2 spec. have low tarsal ratio
Same	12	15.50	13.50	14.70	0.56	3.82	16.49	12.93	Spec. 136 and 139 omitted
Massey, Ont., 23-VI-36	5	17.50	19.00	18.32	0.57	3.10	20.03	16.61	N-1 used for determining $\sigma$

PART II. Arrangement by Taxonomic Category

Category*	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range	
		Max.	Min.				Max.	Min.
<i>canadense</i>	26	9.95	8.28	8.96	0.39	4.34	10.13	7.79
<i>frontale</i>	42	11.20	6.77	9.38	0.92	9.70	11.20	6.77
<i>interpunctatum</i>	20	9.05	6.80	7.98	0.72	9.00	10.14	5.28
<i>heterotarsale</i>	22	9.22	6.18	7.59	0.87	11.57	10.23	4.95
<i>gildersleevei</i>	17	10.70	9.35	10.10	0.39	3.88	11.20	8.85

\*These figures are given in actual mm. while the locality figures are in eye-piece cross-hatch units; 20 cross-hatch units=9.35 mm. The high V is due to seasonal variation except for *canadense* which is probably too low because most of the 26 specimens belong to the Aylmer series. *S. gildersleevei* is an early season species whose emergence period is short.

data, it is not known just what is the exact range of any one of these populations. Apparently *heterotarsale* is not present in southern Ohio, Indiana, or Illinois, although a series from Amity, Ind., 2.VI.40, appears to be typical *heterotarsale*. Individuals seen from southern Ohio, Indiana, and Illinois, and from Oklahoma, Missouri, and Kansas all belong to *interpunctatum*. With considerable certainty, it can be said that *heterotarsale* does not overlap the entire *interpunctatum* range.

It is probable, but not definitely known, that a similar but obverse relationship exists in the distribution of *heterotarsale* and *canadense*, i. e., that at the eastern and northern edges of the range *canadense* exists alone. There is, however, another population that meets with *canadense*, namely *frontale*. This seems to be the typical population of the lowlands of the Hudson River drainage and other eastern United States rivers. The holotype of this species was collected in the late summer (August). Emergents earlier in the season should be expected to be darker and probably larger. This is exactly what is found to be the case and these darker individuals are almost impossible to separate from *canadense* since the dark coloration tends to obscure the stigmal spots, etc., that differentiates *frontale* from *canadense*. As indicated above, a series from Lexington, N. Y., 11.VI.38, which appears to be relatively typical *frontale*, has a mean, a standard deviation and a coefficient of variation very close to those of *canadense* from Aylmer, Que. From Sloatsburg, N. Y., 4.VI.33, after a specimen of *heterotarsale* had been excluded, a series gave an M of 2.63 and a V of 12.60. These specimens have the facies of *canadense*. Thus, while it is possible to separate *frontale* from light colored *canadense*, it is impossible to tell typical *canadense* from dark *frontale*. Probably true *canadense* extends down the Appalachian highlands but is replaced in the lowlands by *frontale*.

The general conclusions as listed above have been based not only on tarsal ratio but also on wing length and the ratio derived from the ♂ fore wing length/first tarsal segment of ♂ fore leg length (called wing/tarsal ratio for short). These statistics support the tarsal ratio but are also of interest in their own right. Wing length (Table II) shows much less variation than does tarsal ratio, and thus has a lower coefficient of variation. A typical *canadense* (Table II), Aylmer, Que., series, has a wing length V of 3.21; *frontale*, Lexington, N. Y., series, a V of 4.19; and *interpunctatum*, New Harmony, Ind. (Louisville, Ky., specimens excluded) a V of 2.90. The series from the Lachine Rapids, Montreal, Que., displays a high V of 5.70 and when the lightly pigmented specimens (abdomens 0 and 1) are separated from the dark (abdomens 2) the V remains high for the light, but drops to 2.8 for the darker individuals. This is exactly parallel to what happened with the tarsal ratio. Note should be given that specimen No. 3 had broken wings and could not be included in the wing measurements. The Bluffton, Ind., series also shows a high V which drops when two long winged individuals are omitted. One of these, No. 136, is a light *canadense* individual that was considered in the tarsal ratio discussion. The other one, No. 139, however, has a *heterotarsale* type tarsal ratio. The Sloatsburg, N. Y., series displays a high V due to two specimens with long wings (No. 83 and No. 87) but No. 81, which was responsible

for the high tarsal ratio V has a wing of average length. The combined New Harmony-Louisville series of *interpunctatum* shows clearly the effect of seasonal variation. The Louisville specimens were collected later in the season than were the New Harmony specimens; although the New Harmony individuals were collected in different years, it was

TABLE III  
RATIO OF  $\frac{\text{MALE FORE WING LENGTH}}{\text{1ST SEGMENT } \sigma \text{ FORE TARSUS}}$  \*

PART I. Arrangement by Locality

Locality and Date	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range		Notes
		Max.	Min.				Max.	Min.	
Lachine Rapids, Que., 1-VII-38	22	9.46	4.46	6.28	1.72	27.80	11.44	1.12	All specimens
Same	16	7.00	4.46	5.48	0.73	13.29	7.67	5.37	Spec. with 0 and 1 abdomens
Same	6	9.46	6.50	8.42	0.94	11.20	10.93	5.90	Spec. with 2 abd.; $\sigma$ det. by N-1
Aylmer, Que., 26-VI-38	22	10.26	7.40	9.19	0.77	8.36	11.49	4.60	All spec. with thor. and abd. of 2 or 3
Louisville, Ky., 22-VII-40; New Harmony, Ind., 16-VI-36 and 30-V-40	9	11.70	9.25	10.57	0.75	7.10	12.82	8.37	$\sigma$ det. by N-1
Sloatsburg, N. Y., 4-VI-33	12	11.19	6.50	9.26	1.37	14.95	13.37	5.15	
Lexington, N. Y., 11-VI-38	11	11.15	6.50	9.58	1.36	14.60	13.66	5.50	
Bluffton, Ind., 20-VII-29	9	11.20	3.66	6.41	2.75	42.70	14.86	2.04	See text

PART II. Arrangement by Taxonomic Category

Category	Total Spec.	Observed Range		M	$\sigma$	V	Estimated Range		
		Max.	Min.				Max.	Min.	
<i>canadense</i>	26	10.25	7.00	9.08	0.82	9.02	11.54	6.62	
<i>interpunctatum</i>	22	12.50	7.00	9.96	1.43	14.45	14.28	5.64	
<i>frontale</i>	33	13.50	6.50	9.37	1.52	16.40	13.93	4.81	
<i>heterotarsale</i>	21	6.50	3.50	5.48	0.88	16.14	8.13	2.82	

\*This ratio was determined by dividing the scale ratio of the wing by the scale ratio of the tarsal joint.

at approximately the same time seasonally. Combined, the V is high due to the small size of the late-season Louisville specimens, but as soon as the Louisville series is removed the V drops. Finally, the Massey specimens, although only five in number, give a V of 3.10.

The wing length/first segment of the  $\sigma$  fore tarsus ratio (called for brevity the wing length/tarsal ratio) presents a picture similar to that

shown by the wing and tarsi separately. The co-efficient of variation shows greater range (Table III) than do those of the other measurements, varying from 7.10 for the *interpunctatum* specimens from Louisville and New Harmony to 42.70 for the Bluffton series. Actually, the latter series when plotted shows three distinct groupings: (1) Five specimens which show a ratio of 3.66 to 4.76—all of these specimens have "0" abdomens and thoraces. (2) Three specimens with ratios of 7.85 to 8.57—all three of these specimens (No. 136, No. 139, and No. 151) were considered in Tables I and II. (3) Finally, specimen No. 136, the most darkly pigmented specimen of the whole series, has a ratio of 11.20.

To supplement the picture of each valid subspecies, a series of typical individuals of every subspecies has been selected, utilizing individuals from all parts of the range and all emergence dates available. The statistics for these are given in Tables I, II, and III. Note also that the estimated range for each character has been determined by adding or subtracting  $3\sigma$  from the M. The coefficient of variability indicates that *canadense* is perhaps the least variable while *heterotarsale* and *frontale* are the most variable. The *canadense* figures are perhaps too low, due to the fact that the most of the specimens in the typical series of *canadense* came from the Aylmer series. The statistics for the other two subspecies are probably more reliable. As an added check to the validity of these findings, a number of specimens of *S. gildersleevei* have been measured and the statistics derived compared with those of the four subspecies. While they show less variability than any one of the four subspecies, the differences are not exceedingly great or beyond expectation since *S. gildersleevei* is a distinct, uniform appearing, geographically and ecologically restricted species.

In considering these series, the assumption has been made on the basis of coloration, size, markings, etc., that certain series, e. g., Aylmer, Lexington, Massey, and New Harmony represent samples drawn from populations that are sufficiently different to be allocated to different taxonomic populations. The same assumptions were made also for the series that was used to estimate the four subspecies. The statistics derived from these series show them all to have coefficients of variation that compare rather closely in magnitude and also compare closely with *Stenonema gildersleevei*, a distinct population for which ample and adequate evidence is available that it represents a different species. By utilizing the statistics derived from the two ratios and the wing length measurements, the question can now be studied as to whether, on the basis of these three characters at least, these various samples could have been derived from populations with the same means and variance, i. e., could they have come from one population? For this analysis, the following formulae were used:

$$1. \quad \sigma d = \frac{N_1}{N_2} \sigma^2 M_1 + \frac{N_2}{N_1} \sigma^2 M_2, \text{ in which } \sigma M = \frac{\sigma}{\sqrt{N}}$$

$$2. \quad D = M_1 - M_2$$

$$3. \quad K = \frac{D}{\sigma d}$$

The assumption is made that where  $K < 2$ , the difference is not significant, i. e., the two samples could be drawn from the same populations. If  $K > 3$ , the difference is significant,  $K > 2.5$  probably significant and  $K > 2$  possibly significant.

It can be seen (Table IV) that the Aylmer and Louisville plus New Harmony series are, on the basis of the tarsal ratio ( $K=2.30$ ), possibly different, but that on the basis of wing length ( $K=1.08$ ) the Aylmer and New Harmony series certainly do not have a significant  $K$  value. The

TABLE IV  
VALUES FOR  $K$

Locality and Date	2nd Tarsal Segment 1st Tarsal Segment	Fore Wing	♂ Fore Wing Length 1st Seg. ♂ Fore Tarsus
Aylmer, Que., 26-VII-38..... Louisville, Ky., 22-VIII-40..... New Harmony, Ind., 16-VI-38.. } . . . New Harmony, Ind., 30-V-40 .. }	2 30	1 08*	
Aylmer, Que., 26-VI-38 Lexington, N. Y., 11-VI-38	0 815	6 05	
Lexington, N. Y., 11-VI-38 Massey, Ont., 23-VI-36	8 17	6 68	
Lachine Rapids, Que., 1-VII-38 (spec. with abd. 0 and 1, No. 3 omitted); Same (spec. with abd. 2)	5 56	0 83†	
Taxonomic Category			
<i>frontale</i> <i>heterotarsale</i>	13.32	6.89	10.35
<i>frontale</i> <i>interpunctatum</i>	2.76	2.55	3.64
<i>frontale</i> <i>canadense</i>	0.48	1.52	1.34
<i>heterotarsale</i> <i>interpunctatum</i>	18.05	0.54	13.22
<i>heterotarsale</i> <i>canadense</i>	20 75	26.85	13 08
<i>interpunctatum</i> <i>canadense</i>	5 10	1 57	5.22

\*Only New Harmony specimens involved (Louisville omitted), since seasonal variation of wing length would confuse picture.

†Specimen No. 3 included for wing measurements.

Aylmer and Lexington series have a significant  $K$  for wing length (6.05) but not for the tarsal ratio (0.815). With the Lexington and Massey series, the  $K$  is highly significant for both wing length and tarsal ratio. Most interesting is the Lachine Rapids series which, when divided on the basis of light abdominal coloration (0+1 for one series and 2 for the other) shows a significant  $K$  for the tarsal ratio but not for the wing length.

Turning to the various selected subspecies series, we find that only in the case of *frontale* and *canadense* is  $K$  of an insignificant value for all

three factors, i. e., tarsal ratio, wing/first tarsal ratio, and wing length. Obviously the two series studied could have come from the same population so far as these characters are concerned. For all the other pairs, at least one and more often all figures are significant, i. e., the samples could not have been drawn from the same population. It must be remembered that these figures apply only to certain characters and that there may be other characters which will clearly separate and distinguish the two populations under consideration.

On the basis of all the data available, there seem to be four distinct populations and the names *canadense*, *frontale*, *interpunctatum*, and *heterotarsale* legally and logically apply to these groups. All evidence, both qualitative and quantitative, indicate that these four populations are subspecies. Three of these subspecies (*canadense*, *frontale*, and *interpunctatum*) are definitely geographical subspecies, but the fourth (*heterotarsale*) may at present be separated from the other three ecologically rather than geographically, since it dwells in at least part of the range of all three other subspecies. *Canadense*, *frontale* and *interpunctatum* all reach the peak of their emergence in the late spring and early summer, while *heterotarsale* reaches its peak of emergence much later in the summer. Further, *heterotarsale* nymphs need a different type of environment than does *canadense*, e. g., *heterotarsale* lives in the lower reaches of a stream and *canadense* lives further up the stream. This indicates that there are considerable physiological differences between the nymphs of at least these two subspecies. Certainly there must be strong selective action being applied to keep these two subspecies distinct, or they long ago would have fused into one highly variable population. Probably this selective pressure is exerted upon the nymphal rather than the adult populations.

Just how the present distribution of the four subspecies arose is not completely clear, but at least part of the history since the Pleistocene glaciation can be hypothesized. At the time of the glaciation, probable *canadense* was the highland, cool stream form of the east with a closely related *frontale* population occupying the lowlands of the eastern coastal area. In the Mississippi Valley, an *interpunctatum* population emerging early in the summer dwelled in the southern lowlands with a *heterotarsale* population further to the north, a population that emerged later in the season than *interpunctatum*. When the glacier retreated, *canadense* moved north and also west along the Great Lakes, while *heterotarsale* also invaded the same area but at lower elevations. Thus, the present Great Lakes and their glacial predecessors served as a broad highway for the distribution of these two subspecies and, due to different ecological demands, they were able to live in the same geographical area and still maintain their integrity. The Atlantic coastal dwelling *frontale* stock was faced, when the glacial ice melted and the level of the ocean rose, with a much reduced territory while the "warm water" *interpunctatum* followed behind *heterotarsale* and eventually came into contact not only with *heterotarsale* but also with *canadense* which had geographically interdigitated with *heterotarsale*. In this area, there is the confusing picture resulting actually from the interbreeding of three populations. It is from this mixed population that

the greater majority of the species which have been synonymized have been derived, for with the exception of *pallidum*, the types of all these species were collected in this area.

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APES, GIANTS AND MAN, by FRANZ WEIDENREICH. Pages vii+122, 1946. The University of Chicago Press. Price \$2.50.

For many years our knowledge of the evolution of man was derived from the logical analysis of his relation to the other primates, supported by rather meager evidence from a few significant fossil remains. *Pithecanthropus erectus*, the ape-man of Java, was the one striking primitive ancestor, while Heidelberg man, Neanderthal man and Cro-Magnon man were transitional early human forms. The actual link with more primitive anthropoid stock was lacking and the precise relations of anthropoid and human ancestral lines was therefore uncertain. Well before the second World War the discovery of *Sinanthropus pekinensis* in China added considerably to our knowledge of the level of human evolution previously illustrated only by *Pithecanthropus*, but left the same gap between man and his anthropoid precursors.

Weidenreich's book discusses impressive additions to this fossil record which might have been made known earlier but for the intervention of the war. Java and China again are the sources of the important remains. *Gigantopithecus* from China and *Meganthropus* from Java fill the all-important gap as manlike creatures still more primitive than *Pithecanthropus* and *Sinanthropus*. They are interpreted as human remains, but of such primitive characteristics that they indicate the actual transition from the anthropoid ancestral line.

With these additions the author is enabled to offer a very convincing explanation of the evolution of the primates. As early as the Miocene the simiid stock apparently began its differentiation, giving rise to one line of descent represented by the fossil *Dryopithecus* which was possibly ancestral to the existing Simiidae and to another which produced the australopithecine forms and the human species. The gibbons probably diverged at an even earlier period. The combination of simiid and human characteristics in *Australopithecus* leads to the conclusion that these creatures were an isolated branch which became extinct without contributing to the formation of any existing species. In the human line of descent *Gigantopithecus*, *Meganthropus*, the pithecanthropine forms and the sequence of human remains form a sufficiently connected series to tax the debating capacity of the fundamentalists. They leave no reasonable doubt of the gradual transition already established, although they introduce another consideration in the apparent reduction of size as modern man has evolved.

The book is technical but not too technical. It arouses admiration even in a scientific mind of the detailed precision with which the physical anthropologists can interpret the meager remains of some of these early species and presents the results comparatively in a most clear and convincing form. It necessitates some revision of earlier concepts, particularly in the evolution of the brain, but even in such points it gives the impression of conservative judgment and dependability.

The author predicts a rich future in the pursuit of investigations in the Oriental region. We can only hope that he will not be impeded in the work now that the war is over and that before many more years have passed we may have other contributions from his pen.—A. W. L.

## NOTES AND KEYS TO THE NEUROPTERA OF MISSOURI

RICHARD C. FROESCHNER

The Neuroptera of Missouri have never been treated as a unit. In fact, our card catalogue of Missouri insects contains literature records for only seven of the thirty-seven species here recorded for the state. The probable occurrence of six more species raises our grand total for the order to forty-three species. Undoubtedly some species not considered here will eventually be found in the state and raise the number still higher. However, we have found from experience with other groups that by the time three-fourths of the probable list has been accumulated, additions are very slow in appearing and further delay in preliminary publication gains very little. Therefore, we are publishing this with the hope that it will not only make our findings available to others, but will also lay the groundwork for more intensive study by other students in the state.

As is usual in this kind of a study, one relies on the work of others to supplement his own. In accumulating records I have had the co-operation of the following men who have kindly granted me use of collections in their care: Dr. L. Haseman of the University of Missouri, and Mr. J. A. Denning of the State Department of Agriculture. In addition, Dr. E. P. Meiners and Messrs. W. S. Craig, W. R. Enns, C. C. Goff and H. I. Rainwater have allowed me access to their personal collections. To all these men I am sincerely grateful.

Records of all data for which I am not personally responsible are indicated by the collector's initials, as in the following list: C. C. Goff, C. W. Wingo, E. H. Froeschner, E. P. Meiners, G. J. Jones, H. I. Rainwater, R. I. Wakeman, W. K. Clark, W. Murray, W. R. Enns, W. S. Craig and W. W. Smith.

For technical help with some of the problems I am deeply obliged to Dr. F. M. Carpenter of Harvard University, Dr. E. A. Chapin of the National Museum and Dr. R. C. Smith of Kansas State College.

The illustrations were done by my wife, Elsie Herbold Froeschner. The full figures as well as the wing of *Mantispa* are all original. The rest of the wings were redrawn from other authorities, as follows: Banks 1907—*Conwentzia*, 1927—basal parts of Myrmeleontid wings; Carpenter 1940—*Boriomyia*, *Lomamyia* and *Sisyr*; Comstock 1936—*Symphorobius*, *Chrysopa*, *Myrmeleon* and *Ululodes*.

All the difficult venational characters are graphically explained by these figures. However, one character might be profitably explained. The gradate veins are cross-veins which are usually arranged in one or two transverse series across the wings—an outer series near apical fourth and an inner series nearer the middle—as best seen in fig. 12. The number in each series may be greatly reduced and may not form such a regular series or they may be entirely absent.



## KEY TO THE MISSOURI FAMILIES OF NEUROPTERA

1. Prothorax longer than broad; fore legs fitted for grasping, i.e., femora swollen and with prominent spines and teeth on lower margin, *Mantispidae*
- Prothorax shorter than broad; legs simple. . . . . 2
- 2.(1). Antennae either gradually enlarged toward apex or filiform with a distinct terminal knob. . . . . 3
- Antennae simple and filiform; females without an exerted ovipositor. . . . . 4
- 3.(2). Antennae not or only very slightly longer than head plus thorax; wings with a greatly elongated cell immediately behind junction of Sc and  $R_1$  (Fig. 17). . . . . *Myrmeleontidae*
- Antennae at least three-fourths as long as the entire length of the body; cell behind junction of Sc and  $R_1$  not elongated (Fig. 15). . . . . *Ascalaphidae*
- 4.(2). Wings with numerous costal cross-veins (Figs. 9-13), but not covered with a whitish powder; length more than 5 mm. . . . . 5
- Wings without a series of costal cross-veins (Fig. 14), but covered with a whitish powder; length not over 4 mm. . . . . *Coniopterygidae*
- 5.(4). Two or more branches of Rs arising from apparently fused stem of  $R_1$  and Rs in front wings (Fig. 12). . . . . *Hemerobiidae*
- All branches of Rs arising from a single Rs stem (Fig. 13). . . . . 6
- 6.(5). Costal cross-veins forked in fore wings (Fig. 9). . . . . *Berothidae*
- Costal cross-veins not forked in fore wings. . . . . 7
- 7.(6). Sc and  $R_1$  fused before reaching margin of wing (Fig. 13); gradate veins absent (Fig. 13). . . . . *Sisyridae*
- Sc and  $R_1$  extending separately to margin of wing (Fig. 11); gradate veins present (Fig. 11). . . . . *Chrysopidae*

## Family Mantispidae

## KEYS TO MISSOURI GENERA AND SPECIES

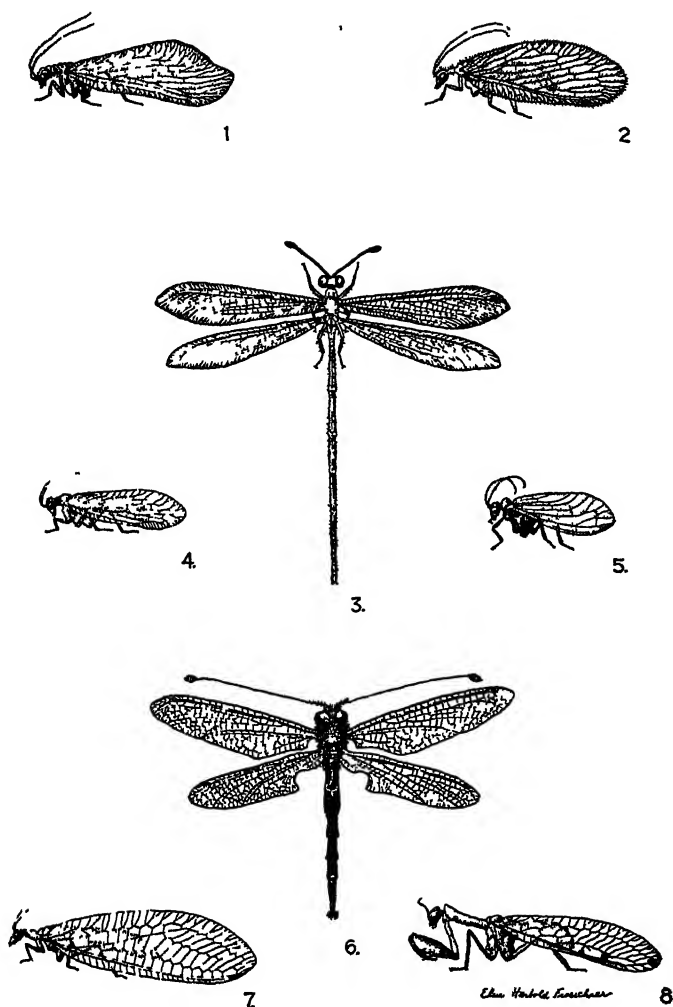
1. Radial cells long and narrow, especially the basal two; anterior half or more of wings distinctly clouded with fuscous. . . . . I. *Climaciella*
- Radial cells short, basal two relatively broad; wings never clouded with fuscous as above. . . . . II. *Mantispa*
- I. *Climaciella* Enderlein
1. Color brown, usually distinctly marked with yellow; all wings with anterior half or more covered by a brownish cloud; anal vein of fore wing branched; length of fore wing 10-12 mm. . . . . 1. *brunnea*
- II. *Mantispa* Illiger
1. Fore wings with one fuscous spot near apex and two just behind  $R_1$  just posterior to stigma; length of fore wing 9-20 mm. . . . . 2. *interrupta* (Fig. 8)
- Fore wings without fuscous spots; length of fore wing 12-15 mm. . . . . 3. *sayi*

## NOTES ON MISSOURI MANTISPIDAE

1. *Climaciella brunnea* (Say). This species is rare in local collections. A single individual was found in a dense weed growth along a stream bank through a woods near St. Louis on July 13. Malt-baited codling moth traps yielded several specimens in Lawrence County during July (WWS).

2. *Mantispa interrupta* Say. This species has been swept in some numbers from isolated oak trees and from along edge growth adjacent to oak woods. Adult records extend from June 14 to September 26. Buchanan, Boone, Jefferson, (EPM), Johnson, Macon, Oregon, Ste. Genevieve and Vernon counties.

3. *Mantispa sayi* Bks. A lone individual was taken from malt-baited codling moth traps in Lawrence County on June 6 (WWS).



1. *Lomamyia banksi*,  $\times 2$ . 2. *Hemerobius humulinus*,  $\times 3$ . 3. *Hesperoleon abdominalis*,  $\times 1$ . 4. *Climacia areolaris*,  $\times 3$ . 5. *Conwentzia hageni*,  $\times 4$ . 6. *Colobopterus excisus*,  $\times 1$ . 7. *Chrysopa nigricornis*,  $\times 2$ . 8. *Mantispa interrupta*,  $\times 1\frac{1}{2}$ .

## Family Myrmeleontidae

## KEYS TO MISSOURI SUBFAMILIES, TRIBES, GENERA AND SPECIES

1. Fore wing with  $A_2$  forming a fairly even curve and connected to  $A_3$  by a short cross-vein or united to it for a short distance (Figs. 18 and 19).  
Dendroleoninae..... 2
- Fore wing with  $A_2$  beginning and extending close up to  $A_1$  and then turning sharply down to join  $A_3$  (Fig. 20)..... 4
- 2.(1). Tarsal I at least as long as II plus III; Cu of fore wing united to  $A_1$  by a short, oblique fork (Fig. 19). Dendroleonini..... I. Dendroleon
- Tarsal I shorter than II plus III; Cu of fore wing not connected to  $A_1$ .  
Brachynemurini..... 3
- 3.(2). Tibial spurs absent..... II. Cryptoleon
- Tibial spurs present; costal area of fore wing with but one series of cells on basal half; front femora without rows of bristles above,  
..... III. Hesperoleon
- 4.(1). Hind wing with but one, or rarely two cross-veins before origin of Rs, latter point before cubital fork. Macronemurinae..... 5
- Hind wing with four or more cross-veins before origin of Rs, the latter usually beyond cubital fork (fig. 17); tarsal I longer than broad; tarsal claws scarcely curved. Myrmeleontinae..... VI. Myrmeleon
- 5.(4). Hind wing with a large, dark spot near apex; legs slender; femora cylindrical..... IV. Glenurus
- Hind wing without large spot near apex; legs stout, femora slightly thickened..... V. Psammoleon

## I. Dendroleon Brauer

1. Both front and hind wings marked with conspicuous brown spots and blotches; fore wing 25-31 x 7-8.8 mm..... 4. obsoletum

## II. Cryptoleon Banks

1. Costal area of fore wing with a single row of cells throughout most of its length; wings very lightly marked, not maculate between Sc and R; fore wing 20-23 x 5.2-6 mm..... 5. signatum

## III. Hesperoleon Banks

1. Pronotum with broad, entire, brown median line; tibial spurs not reaching apex of tarsal I; fore wing 21 x 5-7 mm..... 6. irregularis
- Pronotum with median brown stripe divided medially by a pale stripe; tibial spurs as long as tarsals I plus II; fore wing 21-27 x 5-7 mm.,  
..... 7. abdominalis (Fig. 3)

## IV. Glenurus Hagen

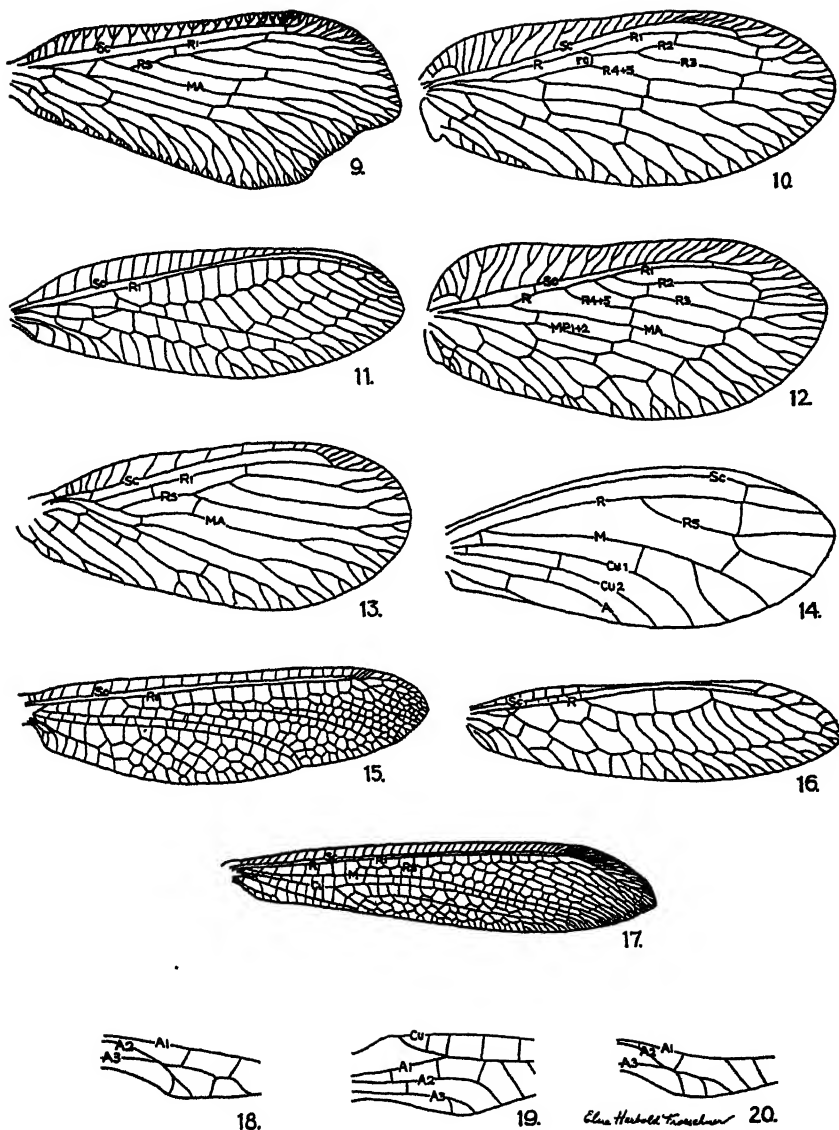
1. Extreme tips of wings dark; subapical area of fore wing whitish with a rosy tint; legs dark; fore wing 34-47 x 9-15 mm..... 8. gratus

## V. Psammoleon Banks

1. Tarsi and mid and hind femur in part pale; tibial spurs longer than tarsals I plus II; fore wings with two dark, nearly parallel streaks; fore wing 29-31 x 6-7.5 mm..... 9. guttipes

## VI. Myrmeleon Linnaeus

1. Cells between  $R_1$  and Rs much longer than cells behind the Rs; fore wing 22-36 x 5.8-8 mm..... 10. immaculatus
- Cells between  $R_1$  and Rs equal to or subequal to those behind Rs (Fig. 17); veins dotted..... 2
- 2.(1). Rs arising but slightly beyond fork of Cu; clypeus entirely pale; lateral lobes of pronotum at least partly dark; fore wing 22-35 x 5.8-8 mm.,  
..... 61. mobilis
- Rs arising much beyond fork of Cu; marks on clypeus and all of vertex and mesonotum dark; fore wing 22-29 x 4.9-7 mm..... 12. crudelis



9. Fore wing of *Lomamyia*. 10. Fore wing of *Symphorobius*. 11. Fore wing of *Chrysopa*. 12. Fore wing of *Boriomyia*. 13. Fore wing of *Sisyra*. 14. Fore wing of *Conwentzia*. 15. Fore wing of *Ululodes*. 16. Fore wing of *Mantispa*. 17. Fore wing of *Myrmeleon*. 18, 19, 20. Characters in anal area of fore wings of Myrmeleontidae.

## NOTES ON MISSOURI MYRMELEONTIDAE

4. *Dendroleon obsoletum* (Say). Just two specimens of this species are at hand from Missouri. One was collected in Oregon County (WKC) and the other was found dead on a window sill in an abandoned building in St. Louis. Hagen (1861) lists it for "St. Louis" under the generic name *Myrmeleon*.

5. *Cryptoleon signatum* (Hag.). With a recorded range that extends as far west as central Illinois, this species forms a "probable" for our fauna.

6. *Hesperoleon irregularis* (Curr.). This species has been recorded to both the east and west of us in Illinois and Kansas and so will undoubtedly be found to occur in Missouri.

7. *Hesperoleon abdominalis* (Say). This is by far the most common of the Missouri Myrmeleontidae. Adults of this poor, low-flying species are to be encountered along roadsides, in weedy fields, at edges of woods and along stream banks between June 10 and August 18. Adair (EHF), Buchanan (RIW), Carter, Henry, Mississippi, Morgan, Nodaway, Oregon, Perry (EHF), Pike (WSC), St. Louis, Schuyler and Stoddard counties.

8. *Glenurus gratus* (Say). Dr. E. P. Meiners collected numerous specimens at rest on tree trunks in a woods in St. Louis County on July 5, 12, 29, 30 and 31. Hagen (1861) listed this for "St. Louis" under the generic name *Myrmeleon*. Banks (1892) placed it, with some doubt, in the genus *Dendroleon* and recorded it for "Mo."

9. *Psammoleon guttipes* Bks. Of the two available Missouri specimens, only one has full data. It was collected in Miller County on August 16.

10. *Myrmeleon immaculatus* DeG. Our adult specimens were all collected in the period between May 23 and September 15. Rau (1926) records it for "Wickes" in Jefferson County. Boone, Lawrence, St. Louis and Taney counties.

11. *Myrmeleon mobilis* Hag. This species, which Banks lists only from Alabama and Georgia, is included in our list on the basis of a record by Rau (1926). The material, which was collected in Jefferson County, was identified by Caudell, apparently at the same time that he determined the more common *M. immaculatus* for Rau. This seems to indicate that there were two species involved so this might possibly be correct. Dr. Chapin, in kind reply to my request, searched through the National Museum's series of this genus but could find no Rau material there. Final confirmation of the Missouri occurrence of this species now becomes a problem for future collecting.

12. *Myrmeleon crudelis* Wlk. One specimen was swept from a woods near the Lake of the Ozarks in Camden County on June 21.

## Family Ascalaphidae

## KEYS TO THE MISSOURI GENERA AND SPECIES

1. Eyes entire, not divided by a horizontal groove.....I. *Neuroptynx*  
Eyes divided by a horizontal groove.....2
- 2.(1). Hind wing with posterior margin suddenly and deeply emarginate at basal fourth (Fig. 6).....II. *Colobopterus*  
Hind wing with posterior margin gently sloping to base, not suddenly emarginate.....III. *Ululodes*

I. *Neuroptynx* McLachlan

1. Front wing with a strong thumb-like projection near base of hind margin, 13. *appendiculatus*

II. *Colobopter* Burmeister

1. Antennae not reaching beyond stigma; wings clear hyaline; forewing 28-30 x 8 mm. 14. *excisus* (Fig. 6)

III. *Ululoides* Currie

1. Antennae reaching or surpassing apex of wings; stigma black; fore wing 25-29 x 6.5-7.5 mm. 15. *macleayana hageni*  
Antennae not surpassing stigma; stigma milky-white or yellow; fore wing 29-32 x 7-8 mm. 16. *quadrifasciata*

## NOTES ON MISSOURI ASCALAPHIDAE

13. *Neuroptynx appendiculatus* (Fab.). But a single Missouri specimen was seen during this study. It was collected in Jefferson County on July 7 (EPM).

14. *Colobopter excisus* Hag. Of the several specimens that have passed through my hands during this study, only one had any ecological data attached. That one was collected "at lights" (WWS). However, it should not differ in habits from the other members of the family. Adult records at hand extend from June 11 to August 2. Buchanan (CCG), Jefferson (EPM), Lawrence (WWS), and Oregon (WKC) counties.

15. *Ululodes macleayana hageni* Weele. Under a synonym, *U. hyalina* (Latr.), this species is listed by Knetzger (1908) as having been taken in St. Louis during July. We have no specimen-records, but it is undoubtedly a member of our fauna.

16. *Ululodes quadrifasciata* (Say). Although most of the adult specimens were taken while sweeping low branches of isolated trees or in open woods, one was observed at rest in the position so characteristic of this family: body resting lengthwise to the perch, wings held roof-wise and antennae extended straight forward. One larva of this was found on the surface of open rocky soil on an Ozark hill. When disturbed it brought its legs in close to its body, opened its mandibles widely and "played dead." This larva was collected in early October and held out-of-doors during the winter. On April 19 it spun a small, white, silken cocoon and pupated. The imago emerged almost two months later on June 5. Adults have been found from April 23 until July 19. Boone, Carter, Franklin (WRE), St. Louis and Stone counties.

## Family Hemerobiidae

## KEYS TO MISSOURI GENERA AND SPECIES

1. Fore wing with an arcuate or recurrent vein in basal costal area (Figs. 10 and 12) 2  
Fore wing without a recurrent vein in basal costal area, costal margin abruptly narrowed basally. IV. *Micromus*
- 2.(1). Fore wing with no more than four gradate veins in outer series (Fig. 10), I. *Symphorobius*  
Fore wing with five or more gradate veins in outer series. 3
- 3.(2). Fore wing with a cross-vein between MA and MP<sub>1+2</sub> shortly after the origin of the latter (Fig. 12) II. *Borlomyia*  
Fore wing without such a cross-vein. III. *Hemerobius*

I. *Symphorobius* Banks

1. Fore wing with vein  $rc$  present (Fig. 10)..... 2  
Fore wing without vein  $rc$ , its maculations consisting of small, irregular spots distributed rather uniformly over the entire surface; costal area very broad; fore wing 3.5-5.1 x 1.5-2.1 mm.....20. *barberi*
- 2.(1). Vein  $rc$  connecting  $R_{4+5}$  to  $R_{1+2}$  before the origin of  $R_{3+4}$ ; wings brownish, cells margined with darker brown; fore wing 5 x 2 mm...17. *occidentalis*
- 3.(2). Vein  $rc$  connecting  $R_{4+5}$  to  $R_{3+4}$  (Fig. 10)..... 3  
Wings brown, veins unicolorous and narrowly bordered in cells with hyaline; antennae with basal third yellowish, remainder fuscous; fore wing 4-5 x 1.6-2.5 mm.....18. *umbratus*  
Cells of fore wings milky to hyaline, strongly mottled with brown; veins light with a black point at base of each hair; fore wing with basal hind angle and an irregular band across inner series of gradate veins dark brown to black; antennae with basal third blackened, remainder pale; fore wing 3.5-6 x 1.3-2 mm.....19. *amiculus*

II. *Boriomyia* Banks

1. Two transverse brown bands on each fore wing, one across each of the two series of gradate veins; fore wing 4 x 7 mm.....21. *fidelis*

III. *Hemerobius* Linnaeus

1. Median longitudinal pale stripe of pronotum nearly or quite as broad as width of head between eyes; fore wing 6.5-8.5 x 3-3.5 mm.,  
22. *humulinus* (Fig. 2)  
Median longitudinal pale stripe of pronotum reduced to a very narrow line or entirely absent; fore wing 7.5-8 x 3 mm.....23. *stigmaterus*

IV. *Micromus* Rambur

1. Fore wings with inner gradate veins much more than their lengths apart; vertex, pronotum and wings medium to light brown; fore wings 7 x 2.3 mm.....24. *subanticus*  
Fore wings with inner gradate veins never more than their lengths apart, the fourth distad of third; fore wing 9 x 4 mm.....25. *posticus*

## NOTES ON MISSOURI HEMEROBIIDAE

17. *Symphorobius occidentalis* (Fitch). On July 19 a single specimen was collected while at rest on the shaded trunk of an elm tree in Scott County.

18. *Symphorobius umbratus* (Bks.). This species has been previously reported only from Arizona and New Mexico. Our single specimen, a female, was collected in general sweeping along the edge of a woods in Cole County on June 21. Verification of this determination was kindly made by Dr. Carpenter who remarked that even though it was impossible to check male genitalia he thought it was undoubtedly this species.

19. *Symphorobius amicus* (Fitch). This species shows a decided preference for red cedar, *Juniperus virginiana* L., at least the majority of our specimens were collected from trees of that species. Extremes of adult records at hand are April 8 and August 7. Boone, Cape Girardeau, Iron, Ste. Genevieve and St. Louis counties.

20. *Symphorobius barberi* (Bks.). Adults appear to be common from May 13 until July 4. However, we do have a single record for mid-September. Boone, Cole, Crawford, Iron, Laclede, Phelps, Randolph and St. Louis counties.

21. *Boriomyia fidelis* (Bks.). This species has been listed for as far west as southern Illinois and Texas and so probably will be found in Missouri.

22. *Hemerobius humulinus* Linn. Our adult records fall into two groups, one from April 6 until July 7 and the other from September 18 to October 16. They are common during both periods. This may indicate two generations a year or it may indicate hibernation in the adult stage. Boone, Butler, Carter, Cole, Iron, Laclede, Lawrence (WWS), Ste. Genevieve, St. Louis (EHF), Saline and Schuyler counties.

23. *Hemerobius stigmaterus* Fitch. The four specimens studied were dated April 1 and 18, May 6 and October 10, indicating that this species may hibernate as adult. Banks (1905) records a specimen from "Central Mo." Boone and St. Louis counties.

24. *Micromus subanticus* (Wlk.). The few available adult records extend from June 24 until August 2. During June several specimens were found in the base of a grass clump. Instead of attempting to escape by flight they ran into the clump or tumbled to the ground and feigned death. Boone, Howell, Jasper and St. Louis counties.

25. *Micromus posticus* (Wlk.). More common than its congener, this species appears to occur throughout the year, our records being for March, June, July, August, September, October and December. Hibernating individuals have been found in crumpled dead leaves which were still hanging to the trees and among dead leaves on the ground. Bollinger (CWW), Boone, Cape Girardeau (CWW), Greene (HIR), Jefferson, Platte, St. Louis, Scott and Stone counties.

## Family Berothidae

### KEYS TO MISSOURI GENUS AND SPECIES

1. Hind wing with but three gradate veins, the lower one in line with the other two; fore wing with lower gradate vein of outer series not more than its length from the one above it.....I. *Lomamyia*

#### I. *Lomamyia* Banks

1. Males (without prominent external genitalia) with face reddish-brown and aedeagus s-shaped; females (with prominent external genitalia) with a patch of black scales on anterior face of fore coxa; fore wing 10 x 4.2 mm.....26. *banksi* (Fig. 1)

### NOTES ON MISSOURI BERTHIDAE

26. *Lomamyia banksi* Carp. A female was swept from a red cedar tree, *Juniperus virginiana* L., on May 3. A male was collected by sweeping low, weedy growth in an oak woods on August 1. Oregon and Washington counties.

## Family Sisyridae

### KEYS TO MISSOURI GENERA AND SPECIES

1. Rs of fore and hind wings with but one main fork, and that below the stigma; fore wings marked with brown or black.....I. *Climacia*  
Rs of fore and hind wings with two main forks, both much before the stigma (Fig. 13); fore wings uniformly colored.....II. *Sisyr*

#### I. *Climacia* McLachlan

1. Antennae dark brown; head and legs light yellow; fore wing with a spot at apex of stigma, an oblique patch from base of stigma to Rs and one at base between Sc and R dark brown, these sometimes so reduced as to be only indicated by darkening of the veins in these areas; fore wing 5 x 2 mm.....27. *areolaris* (Fig. 4)



II. *Sisyr* Burmeister

1. Head yellow to brown; thorax yellowish-brown to medium brown, abdomen brown; fore wing 6 x 2.5 mm.....28. *vicaria*

## NOTES ON MISSOURI SISYRIDAE

27. *Climacia areolaris* (Hag.). A lone specimen was collected in Taney County on September 15. Its venation differs slightly from that in the wing figured by Carpenter (1940) in that the main fork of Rs occurs basad of the position indicated. In ours it occurs below the proximal end of the stigma. In addition, the wing markings are greatly reduced, being merely suggested by blackening of the veins in the areas on which the maculations are pictured.

28. *Sisyr vicaria* Wlk. Two specimens were taken in a cypress swamp in Dunklin County on May 12. It should be found throughout most of the state.

## Family Chrysopidae

## KEYS TO MISSOURI GENERA AND SPECIES

1. Color predominantly brown to dark reddish-brown; veins of wings spotted with brown; hind wings with one series of gradate veins...I. *Eremochrysa*  
Color green, yellow-green or yellow; wing veins not spotted; antennae separated by a space which is narrower than the width of basal antennal segment.....2  
2.(1). Stigma prominently marked with purplish dots. . . . .II. *Nodita*  
Stigma not dotted with purplish or brown.....III. *Chrysopa*

I. *Eremochrysa* Banks

1. Transverse veinlets of wings alternately spotted with light and dark areas.....29. *punctinervis*

II. *Nodita*

1. Bases of antennae not reddish above; gradate series converging posteriorly, the inner one of five veins.....30. *americana*

III. *Chrysopa* Leach

1. Antennae black on basal half, except segments I and II.....2  
Antennae pale with a dark ring on II or pale throughout.....3  
2.(1). Pronotum not marked with red laterally; antennal I entirely pale.....3  
Pronotum with a longitudinal red line near lateral margins; antennal I with a black stripe above; vertex not marked with black; fore wing 15 x 7 mm.....33. *lateralis*  
3.(2). Clypeus with a black dot on each side; stigma indistinct; fore wing 11-16.5 x 3.5-5.8 mm.....31. *nigricornis* (Fig. 7)  
Clypeus without black spots; stigmata brownish on all wings, 32. *columbiana*  
4.(1). Antennal II with a dark ring; face with an extensive black pattern; fore wing 11-13.7 x 4-5.8 mm.....34. *oculata*  
Antennae entirely pale; face with little or no black.....5  
5.(4). All veins, including cross-veins, pale.....6  
Many of the cross-veins fuscous-black or marked with fuscous black.....7  
6.(5). Genae with a black or dark brown band from lower margin of eye to base of mandible, sometimes also suffused with red; fore wing 10-12.8 x 3.3-4.1 mm.....35. *plorabunda*  
Genae broadly suffused with red but without a black band between eye and base of mandible; fore wing 11-12.8 x 3.7-4.1 mm.....36. *harrisii*  
7.(5). Genae without a colored band between lower margin of eye and base of mandible; fore wing 11-12 x 4 mm.....37. *intacta*  
Genae with a red band between lower margin of eye and base of mandible... 8

- 8.(7). Orange spotting as follows: sometimes a pair on vertex near eyes, at least two pair on pronotum, several on mesonotum and along sides of abdomen; fore wing 9.5-14.5 x 3.1-5.2 mm. .... 38. *quadripunctata*  
No orange spotting on head, thorax or abdomen; radial and costal cross-veins black in middle and green at ends. .... 9
- 9.(8). Color straw yellow with no median, yellow, dorsal stripe indicated; gradates and many other veins marked with black; fore wing 10.4-11 x 3.1-3.5 mm.,  
39. *interrupta*  
Color green or greenish-yellow with a yellow, median, dorsal stripe which is usually distinct; usually only gradates blackened; fore wing 11-11.4 x 3.7-4 mm. .... 40. *rufilabris*

## NOTES ON MISSOURI CHRYSOPIDAE

29. *Eremochrysa punctinervis* (McLach.). This species has been listed for Oklahoma, Kansas, Nebraska and Iowa and so should be found in Missouri.

30. *Nodita americana* (Bks.). Further collecting in Missouri might find this rare species which was described from Alabama and subsequently listed for Kansas and Texas.

31. *Chrysopa nigricornis* Burm. This uncommon species, which occasionally comes to lights, has been collected as adult during April, May, June and September. Boone, Miller, St. Louis, Schuyler (EHF) and Stoddard counties.

32. *Chrysopa columbiana* Bks. No Missouri specimens of this have been noticed in the material which has passed through the author's hands. It has, however, been listed as occurring in Canada, Iowa and North Carolina and so some day may be found in Missouri.

33. *Chrysopa lateralis* Guer. A single specimen was collected in Stoddard County on August 11.

34. *Chrysopa oculata* Say. Between May 3 and October 7, this species, with its numerous color varieties, has proven itself to be the commonest Chrysopid in the State. It is chiefly an inhabitant of fields, gardens and even city lots. It comes freely to lights. The following color forms, which may be separated in the key given below, have already been noted in the available Missouri material: nominal *oculata* Say, *separata* Bks., *chlorophana* Burm. and *illepida* Fitch.

## KEY TO COLOR FORMS OF CHRYSOPA OCULATA SAY

- a. Gradates and usually some of the cross-veins of wings at least in part black. .... b  
Gradates and cross-veins of wings (except some of costal cross-veins in hind wings) light or green; wings broad and rounded at tips. .... *chlorophana*
- b.(a). Black loops under antennae not connected to marks on genae beneath eyes or connection very faint. .... *separata* Bks.  
Black loops under antennae distinctly connected with marks on genae. .... c
- c.(b). Vertex either wholly yellow or with a pair of short, longitudinal black dashes. .... d  
Vertex with four separate blackish spots and usually another one behind each compound eye. .... f
- d.(c). Vertex without any dark spots or only small ones in reddish band above the antennae. .... e  
Vertex with a pair of short, elongate dark lines which are usually connected with reddish band above antennae. .... *illepida* Fitch
- e.(d). No spots at all on vertex. .... *carei* Sm.  
Vertex with small black or brown spots in close connection with the reddish band above the antennae. .... *xanthocephala* Fitch
- f.(c). Most cross-veins brown or black. .... *albicornis* Fitch  
Costal cross-veins darkened only at ends, most cross-veins pale. .... *oculata* Say

As indicated by the following list of counties in which it has been collected, this species can be expected to be found throughout the state: Bollinger, Boone, Buchanan, Butler, Carter (EHF), Chariton (EHF), Clark, Crawford, Dallas, Daviess, Dunklin, Harrison, Holt, Howard, Iron, Jackson, Jasper, Jefferson, Laclede, Lawrence (WWS), Linn, Macon, Mississippi, Newton, Pemiscot, Perry, St. Louis, Scott, Shannon, Stoddard, Stone and Taney counties.

35. *Chrysopa plorabunda* Fitch. The adults of this common species hibernate. They may be found clinging to dried leaves that remain on the plants or among debris on the ground. In the active season they prefer open fields and are to be collected along with *oculata*. We have adult records for every month in the year. C. V. Riley (1870 and 1875) lists it for "Allenton" in St. Louis County. In addition to the nominal form, the variety *californica* Coq. has been found among the material reviewed. These two forms may be separated by the following couplet:

Little or no red bordering the narrow black bands on genae,

nominal *plorabunda* Fitch  
Considerable reddish suffusion along the black bands and extending over genae  
and sides of clypeus.....variety *californica* Coq.

Adair, Boone, Buchanan, Cass, Cole, Crawford, Dade, Franklin, Harrison (EHF), Jackson, Jefferson, Lawrence (WWS), McDonald (EHF), Macon, Maries, Miller, Nodaway, Osage, Phelps, Pike, Pulaski, Ste. Genevieve, St. Louis, Saline (EHF), Shannon and Taney counties.

36. *Chrysopa harrisii* Fitch. To date, only the nominal form of this species has turned up in the material studied. It is uncommon and has been collected during June, October and early November. McDonald, Pulaski and Schuyler (EHF) counties.

37. *Chrysopa intacta* Nav. The specimens here placed under this name agree rather well with Smith's (1932) translation of the original description, except that the color is yellowish rather than greenish. As Smith says, this is a "very general description" which results in a poorly defined species. However, since our specimens fit it better than any other, especially in the absence of a colored band between lower margin of eye and base of mandible, I am leaving them under this name. The extremes of dates are June 20 and July 21. Newton, Pemiscot, Reynolds and St. Louis counties.

38. *Chrysopa quadripunctata* Burm. The Missouri specimens at hand were collected during July and September in Nodaway, Scott, Stoddard and Vernon counties, indicating a widespread distribution in the state.

39. *Chrysopa interrupta* Sch. This is another uncommon species in the state. Available specimens were all collected during July and October in Boone, Iron, Lafayette, Newton, Reynolds and St. Louis counties.

40. *Chrysopa rufilabris* Burm. This species is only slightly more common than *interrupta*. Adults have been collected during July, August and September. Boone, Dunklin, Lafayette (EHF), Mississippi, Ste. Genevieve, Saline, Scott, Shannon and Stoddard counties.

## Family Coniopterygidae

## KEYS TO MISSOURI GENERA AND SPECIES

1. In fore wing the cross-vein from Cu runs into M at or beyond the only fork; in hind wing both radial sector and median vein forked,
  - I. *Coniopteryx*  
In fore wing the cross-vein from Cu runs into M well before the fork (Fig. 14)..... 2
- 2.(1). Hind wings small and narrow, not over half the length of the front ones; hind wing with radial sector unforked.....II. *Conwentzia*  
Hind wings only slightly smaller than front pair; hind wings with radial sector forked and median vein simple.....III. *Malacomyza*
  - I. *Coniopteryx* Curtis
    1. Body and wings dark; cross-vein between R and Sc about its length from cross-vein between R and Rs; length 2.6-2.9 mm.....41. *vicina*
  - II. *Conwentzia* Enderlein
    1. Black or brown, wings paler, infused; all Cu and A veins connected by cross-veins (Fig. 14); length 3.6-4 mm.....42. *hageni* (Fig. 5)
  - III. *Malacomyza* Wesmael
    1. Cross-veins in fore wing, except one between M and Cu, very faint, almost invisible; length 2.4 mm.....43. *westwoodi*

## NOTES ON MISSOURI CONIOPTERYGIDAE

41. *Coniopteryx vicina* Hag. Our specimens have been swept from shrub and tree foliage in woods during May and August. Iron, Jefferson, Ste. Genevieve and Scott counties.

42. *Conwentzia hageni* Bks. A single specimen was taken in general sweeping in Ste. Genevieve County (EHF) on April 8.

43. *Malacomyza westwoodi* (Fitch). A lone specimen was found running nervously along a small branch of a wild cherry tree, *Prunus serotina* Erhr., in St. Louis County on May 6.

## REFERENCES

This list includes not only those works which were useful in determining local material but also those containing Missouri records of the order. The latter are indicated by a dagger.

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THE BUTTERFLIES OF WASHINGTON, by BEN V. LEIGHTON. University of Washington Publications in Biology, Vol. 9, No. 2, pp. 47-63, 1946. Price 45 cents.

Faunal lists can be extremely helpful to the taxonomist and they can be a source of worry. Whether they can be wholly one or the other is uncertain because they often include data from old collections which are not dependable and they are subject to the vagaries of identification.

This list inspires confidence since it is sponsored by the department of biology of the University of Washington. It is also carefully annotated, including a suggestion under *Poanes taxiles* that the insect may be incorrectly labelled. In the portion covering the Hesperioidea, with which the reviewer can claim critical familiarity, another identification seems extremely doubtful. *Hesperia viridis* Edwards is a southwestern species easily confused with *pahaska* Leussler which actually ranges from the southwest to the northern tier of states, hence it is almost certain that the record should be credited to the latter species. It is extremely doubtful too that true *Hesperia colorado* occurs in Washington. Regardless of these discrepancies the list should be helpful as a careful summary of Washington records of butterflies and skippers, since the references to specific material are complete and the identifications can therefore be checked.—A. W. L.

ARQUIVOS DE ZOOLOGIA DO ESTADO DE SAO PAULO, VOL. IV. 623. XLIII pages. Departamento de Zoologia da Secretaria da Agricultura, Indústria e Comércio, São Paulo, Brazil. 1946.

This large volume is made up of a series of articles on various groups of animals, including hydroids, birds and fishes as well as insects and other arthropods.

The articles on arthropods include the following titles: Excursão científica a Porto Cabral, margem paulista do Rio Paraná, by Lauro Travassos Filho. Estudos biológicos sobre alguns Lepidópteros do Brasil, Segunda nota suplementar a "Revisão das *Terias* americanas" and Revisão do gênero *Xanthocleis* by R. Ferreira d'Almeida, Técnicas gerais seguidas no estudo da ordem *Mantodea* Burmeister, 1838, and Sobre a família *Acanthopidae* Burmeister, 1858, emend. (*Mantodea*) by Lauro Travassos Filho. Alguns aspectos bionômicos de *Leptopsylla segnis* (Schönh.) (*Suctoria*), by Lindolpho B. Guimarães. Opiliões da coleção do Museu Nacional do Rio de Janeiro and Revisão dos Opilões do Departamento de Zoologia by B. M. Soares.

The reviewer has noted no descriptions of new species in the taxonomic papers but the extent of the material included should make them useful to specialists in the several groups.—A. W. L.

# THE MORPHOLOGY AND MUSCULATURE OF THE LARVAL HEAD OF ANOPHELES QUADRIMACULATUS SAY<sup>1</sup>

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A study of the morphology and musculature of the fourth instar larval head of *Anopheles quadrimaculatus* Say (Diptera: Culicidae) was undertaken to determine the structure and functioning of its component parts. The morphology of the head of this species has apparently never been described. It is the purpose of this paper to present the anatomy of the head and to compare its structures with those found in other mosquito larvae.

Almost all of the numerous papers dealing with the Culicidae are purely taxonomic or bionomic in character. Meinert (1886), Raschke (1887), Nuttall and Shipley (1901), Johannsen (1903), Thompson (1905), Imms (1907, 1908), and Wesche (1910) describe in some detail the various head structures of mosquito larvae. Howard, Dyar, and Knab (1912) summarize the literature up to that time.

This work was undertaken to study the larval head of *Anopheles quadrimaculatus* and to compare it with the results given by Becker (1938) and Cook (1944b). Becker (1938) restricts his work to a study of the mouth brushes, their structure and function in feeding. Cook (1944b) devotes himself largely to the details of head structure of various mosquitoes (*Theobaldia incidens*, *Anopheles maculipennis*, *Lutzia halifaxi*, and *Armigeres malayi*) but fails to adequately describe the workings of the mouth brushes as used in feeding. Becker's interpretation of the mechanism of feeding seems, to the writer, the most tenable and is largely confirmed by the detailed study of the mouth brushes presented later in this paper.

Homologies between the structures present in *Anopheles* and those of other Dipterous larvae have been indicated insofar as this is possible. References to the plates will indicate the great complexity of the palatal and labial regions (figs. 5, 7, 8, 12, 16). The prementum of the labium has deviated far from the condition usually found in more generalized insects. The actual homologizing of its parts may have to be postponed until more information is obtained from examinations of this structure in other larvae of the Culicidae. The various head hairs, antennal, maxillary, and mandibular tufts of setae, and other similar characteristic outgrowths of the cuticula have been omitted from the illustrations.

## MATERIALS AND METHODS

The fourth instar larvae were killed in hot water or in Dietrich's fluid, either of which had been heated to 60° C. The insects were

<sup>1</sup>The author wishes to express her sincere appreciation to Dr. Robert Matheson for suggesting and directing the work done on this problem.

fixed in Dietrich's solution and were stored in 50% alcohol. Actually little storage was necessary as living eggs were obtained from the Tennessee Valley Authority and the United States Department of Agriculture Experiment Station at Orlando, Florida. The larvae were reared in the laboratory, and thus a constant source of fresh material for study was always available.

The larval heads were dissected either in water or in glycerine, although the water medium was found to be preferable. A binocular dissecting microscope was employed and most of the work was done with a magnification of 108 $\times$ . For detailed studies, a compound microscope was used with a magnification of 430 $\times$ .

Complete serial sections of the head at various angles were also made. The sections were cut at 6 $\mu$  and 12 $\mu$  and were stained with Heidenhain's iron haematoxylin. Alcoholic eosin was employed as the counter-stain. Intensive studies of these sections were made to confirm the results obtained by the more gross dissections.

#### MORPHOLOGY OF THE HEAD

The head capsule is composed of the clypeus and the ocular lobes. The median clypeus is bounded posteriorly and laterally by the clypeo-frontal suture, and anteriorly by the clypeolabral suture (figs. 1, 2). Anteriorly in the clypeofrontal suture and next to the bases of the antennae there is present a deep infolding of the cuticula to form a strong internal phragma (pp. figs. 6, 11), the paraclypeal phragma (Ferris, 1943). This structure gives rise to the anterior tentorial arm and the anterior articulation of the mandible. This would seem to be a further development of similar structures found in *Theobaldia* by Cook (1944b). In larvae of this genus, the phragma originates from a fold (the paraclypeal fold) in the cuticula, just lateral to the clypeo-frontal suture. It is thus a part of the antennal segment since it bears the anterior tentorial pit and the anterior articulation of the mandible. In *Anopheles maculipennis*, the paraclypeal fold has "passed into the clypeofrontal suture" (Cook, 1944b). It is safe to surmise that the same development has occurred in the closely related species *A. quadrimaculatus*. The remainder of the antennal segment is not clearly defined from the rest of the cranium.

The eyes are situated laterally on the ocular lobes. The crescent-shaped, heavily pigmented bodies are the primordial ommatidia of the adult. The simple larval eye is located slightly posterior to the forming adult eye, and appears as a round blackened spot in the cuticula.

The ocular lobes comprise the lateral portions of the cranium (ol, fig. 2) and extend around the head ventrally to the premaxillary sutures (pms). The midventral portion of the cranium (fig. 12) is composed of the maxillary segment, although its limits are not clearly defined. The maxillary segment has expanded anteriorly and has developed into a more or less triangular plate, termed the maxillary plate, which overhangs the labium.

From the posterior margin of the head, the median suture extends forward along the mid-ventral line to the maxillary plate. The posterior tentorial pits (ptp, fig. 12) are located laterally in the head capsule to either side of the median suture (ms).

*The Clypeus:* The dorsal portion of the head is quite heavily sclerotized, and is made up of the clypeus and the ocular lobes. The clypeus is a large sclerite covering most of the dorsum of the head. It is bounded posteriorly and laterally by the clypeofrontal suture and anteriorly by the clypeolabral suture (cfs, cls, figs. 1, 2). On its inner face are found the origins of several muscles of importance.

The largest of these are the messorial muscles, (the muscles associated with the movement of the mouth brushes). The inner pair (im, figs. 1, 9) are located in a median and posterior position, while the external pair (em) are placed more anteriorly and laterally. Behind the internal messorial muscles are found the origins of the posterior pharyngeal muscles (ppm). On the central portion of the clypeus originate the median pharyngeal (mpm) and median palatal muscles (mpa). Near the clypeofrontal suture on either side are the lateral pharyngeal muscles (lpm). Anterior to these are the origins of the four pairs of cibarial muscles (cm) (see figs. 1, 9).

There has been some discussion as to whether the area which we have designated as the clypeus is actually the true clypeus or a combined clypeo-frons (Cook, 1944b). It has been variously described by the early morphologists. Meinert (1886) regards this area as the "scutum of the third metamere," Howard, Dyar, and Knab (1912) term it the front or epistoma, while later authors tend to call it the frons.

Snodgrass (1928, 1935) has defined the clypeus as that area of the head on which the dorsal dilator muscles of the cibarium originate. In accordance with this definition, the median dorsal sclerite of the larval head with which we are dealing, can be none other than the true clypeus, as the origins of the cibarial, messorial, and median palatal muscles are found thereon. Cook (1944b) points out that "the clypeofrontal suture is clearly identified by its termination anterior to and mesad of both the anterior mandibular articulation and the anterior tentorial pits."

*The Paraclypeal Phragma and Associated Structures:* Anterior and contiguous to the antennal bases, there is present a deep infolding of the head wall along the clypeofrontal suture. This structure is the paraclypeal phragma. It is continuous with the outer ventral wall of the cranium which extends anteriorly to articulate with the messorial sclerites of the mouth brushes (mes, figs. 9, 11). From its inner edge on either side of the head arise the slender anterior tentorial arms. The anterior tentorial arms are elongate and rather weak in this species. They extend backward in the head to meet the much shorter posterior tentorial arms, which are invaginated from pits on either side of the ventral median suture. The anterior arm bears, somewhat posteriorly along its length, the origin of the antennal muscle (am, figs. 6, 11). This muscle is inserted at the inner and ventral edge of the scape of the antenna. It is the only antennal muscle present and functions as a levator.

Also arising from the inner margin of the paraclypeal fold is another phragma (pab, fig. 6), termed the postantennal buttress (Cook, 1944b). It extends from the paraclypeal phragma, behind the antennal foramen to the cranial wall. Its point of invagination from the head capsule is indicated exteriorly by a small line (pab, figs. 1, 2). It serves along



with the paraclypeal phragma and the tentorium to support and strengthen the cranium.

From the inner edge of the origin of the anterior tentorial arm arises a rod-like sclerite known as the cibarial bar (Cook, 1944b). The cibarial bar (cb, fig. 11) extends ventrally and is fused with the heavily sclerotized rim of the prementum of the labium. In this position, it forms a strong margin around the ventral posterior border of the preoral cavity. Just beyond its point of origin, the cibarial bar bears the anterior articulation of the mandible (aam, figs. 6, 11).

*The Labrum:* The labrum has also been given a variety of names by other workers. The narrow sclerotized strip of cuticula just anterior to the clypeofrontal suture is usually referred to as the clypeus in taxonomic studies. The more or less triangular membranous area just anterior to it has been termed the labrum. As Cook (1944a, 1944b) has pointed out in his recent papers, this narrow area cannot be the clypeus, since there are no muscles originating on its inner face. The cibarial muscles almost always diagnostic of the clypeus (Snodgrass, 1928, 1935) have their origins posteriorly and on the large dorsal sclerite which was designated above to be the true morphological clypeus. The narrow sclerite is believed by Cook (1944b) to be "all that is left of the dorsal sclerotization of the labrum."

The most anterior membranous part of the head may probably contain some portion of the dorsal labral elements. This membranous area (mma, figs. 1, 2, 12) bears laterally the mouth brushes and anteriorly gives rise to a rounded projection on which are borne numerous strong bristles. This projection overhangs the structures found on the palatum, or underside of the labrum. These will be described in detail below.

*The Palatum and Mouth Brushes:* The structure of the mouth brushes and of the various sclerites found on the under side of the labrum have been studied and described by several workers. Meinert (1886), Raschke (1887), Nuttall and Shipley (1901), Thompson (1905), and Imms (1908) have described these structures in some detail and have given accounts of their probable function.

The actual structure of the palatum and mouth brush mechanism has been worked out in recent years by Becker (1938) and by Cook (1944b). Both authors dealt with *Anopheles maculipennis*. The species here described is *Anopheles quadrimaculatus*, but we have found that *A. quadrimaculatus* is practically identical with *A. maculipennis* as described by Becker (1938).

The lateral areas of the membranous portion of the labrum bear the mouth brushes and anteriorly the sclerotized median lobe which overhangs the palatum. Beneath, on the ventral surface of the palatum and separated from the base of the brushes by a narrow membranous fold, are a pair of flat sclerotized plates termed the lateral palatal plates by Cook (1944b) or the subflabellar sclerites of Becker (1938) (lpp, figs. 5, 7, 12). These are articulated posteriorly with the messoroes (mes). Anteriorly there is a membranous break between the lateral palatal plates and the messoroes. Overhanging this connecting membrane is a series of very small spines (figs. 7, 12).

The messoros themselves (longitudinal levers of Becker, 1938) are a pair of sinuous, somewhat twisted plates which are connected anteriorly with the base of the brushes. Upon an arm-like projection in the anterior internal portion of each messor is attached the apodeme of the internal messorial muscle (aim, fig. 5).

To the median side of the articulation of the messoros with the brushes (or flabellae) is attached an apparatus called the transverse girdle (tg) by Becker (1938) which connects the anterior ends of the messoros just beneath the median lobe (ml) of the labrum (figs. 5, 7).

In the mid-ventral portion of the palatum, between the messoros and beneath the transverse girdle, is a slight membranous protuberance. It is supported by a V-shaped sclerotized bar (ppb, fig. 5), termed the posterior palatal bar (Cook, 1944b), or endoskeletal arch (Becker, 1938). From the posterior palatal bar, just lateral of the mid-ventral line, arise two somewhat triangular shaped structures (ta). From these originate two groups of bristles which overhang the entrance to the cibarial cavity (figs. 7, 12). At the point of the V, formed by the posterior palatal bar, is inserted the apodeme of the two slender median palatal muscles (mpa, figs. 5, 9). These muscles originate on the inner central portion of the clypeus (fig. 1). The lateral ends of the posterior palatal bar are attached to the median margin of the messoros. The external pair of messorial muscles are inserted upon apodemes which arise from the ends of the posterior palatal bar close to the point where the latter is articulated to the messoros (aem, fig. 5). Cook (1944b), in his study of *Anopheles maculipennis*, states that both pairs of messorial muscles are inserted on the messoros. This inaccuracy must have arisen from an error in observation as the external messorial muscles are definitely inserted on the lateral tips of the posterior palatal bar. This is further corroborated by Becker (1938), who worked with *Anopheles maculipennis*, and thus the conflicting statements as to the location of these muscles cannot be due to a species difference.

The posterior tapering tips of the messoros are articulated to the ventro-lateral cranial wall, which is the anterior extension of the paraclypeal phragma.

There have been various theories proposed as to the actual working of the mouth brush mechanism. Raschke (1887) believed that the internal messorial muscles functioned as extensors and the external pair as flexors of the brushes. Nuttall and Shipley (1901) state that the brushes are capable of independent action. Howard, Dyar, and Knab (1912) say that by retractor muscle action and subsequent relaxation, the "side picces" are jerked forward and backward. More agreement is found in the papers of Thompson (1905) and Imms (1908). Both maintain that all muscles contract simultaneously to depress the brushes. Upon the relaxation of the messorial muscles, the normal extended attitude of the brushes is regained by virtue of the elasticity of the framework.

Becker (1938) has presented a somewhat different theory of operation which he describes in detail. He states that by the contraction of the internal messorial muscles, the anterior ends of the messoros (near which the latter muscles are inserted) are brought together along the median line. The inverse movement of the posterior portion of the

nessor is automatic, and is brought about "by a deformation of the lateral margin of the clypeus," at which point the posterior end of the messor rests. The transverse girdle, which connects the anterior ends of the messores, helps in bringing their ends together by folding in two and thus "contributes . . . to the formation of the median longitudinal fold, on the lateral slopes of which both flabellae fall." Becker (1938) also says that the transverse girdle directs the motion of the median lobe, which naturally follows, since it is attached anteriorly to this structure. At the posterior portion of the palatum (Becker's epipharynx) is located the median protuberance which forms the permanent part of the median fold on which the brushes fall. The contraction of the paired external messorial muscles inserted on the lateral tips of the posterior palatal bar (aem, fig. 5) assist in the action of the inner messorial muscles (aim, fig. 5). Their contraction is also able to change the position of the posterior palatal bar. According to Becker (1938), the median palatal muscle (mpa, figs. 5, 7, 9) is the antagonist of the external messorial muscle.

It is most probable that Becker's statement of the labral mechanism is correct; this agrees with the writer's interpretation. The external messorial muscles, then, assist the internal messorial muscles by pulling the posterior palatal bar to a more anterior position. Such a position would deepen the longitudinal palatal fold and cause the mouth brushes to be depressed to an even greater extent. The action of the median palatal muscle would return the posterior palatal bar to its original location. By this pull, along with the elasticity of the cuticula, the longitudinal fold would straighten out and cause the brushes to return to their normal position.

The messores themselves can be homologized with the so-called "lateral arms" of Johannsen (1903) found in the larvae of the Chironomidae. In the latter family the messores form a pair of sclerotized arm-like processes which extend posteriorly toward the mouth (Cook, 1944c). They are invaginated in part beneath the palatal surface. The musculature of these structures is the same as that found in larval Culicidae according to Cook (1944c), except that the apodemes are poorly developed. The origins of the four muscles belonging to the messores are located "on the posterior half of the clypeus with the median pair originating slightly anterior to the origins of the median pharyngeal muscles" (Cook, 1944c). This author also says that the messores of *Chironomus* articulate with a transverse sclerite which may be the homologue of the posterior palatal bar of the Culicidae.

*The Mandibles:* The mandibles are, in general, much like those of the typical mandibulate insect. They have deviated somewhat, however, from the generalized type. From the mandible is developed an elongate sclerotized arm which extends ventrally to the cranial wall. The posterior articulation is located at this point. This arm-like projection (ma, figs. 3, 4) also extends around the base of the maxillary palpus (mxp) and thus aids in its support. Such a mandibular arm has also been described by Cook (1944b) in his study of the larva of *Anopheles maculipennis*.

The abductor muscles (mab, figs. 2, 3, 11) are inserted upon an apodeme located on the posterior rim of the mandible, close to the

origin of the arm-like sclerite. The abductor muscle is composed of two major bundles. One originates latero-dorsally on the ocular lobe near the primordial adult eye crescent. The other is divided into two smaller bundles both of which are located more ventrally.

The adductor muscle (mad, figs. 2, 11) is inserted on a large apodeme and is composed of four main groups which may be secondarily divided. These originate laterally and ventrally on the ocular lobes, near the posterior margin of the cranium.

*The Maxillae:* The maxilla is trapezoidal in shape and is composed of the palpus and the stipes, which may include the galea and the lacinia (Cook, 1944b). It is attached to the wall of the head along its entire ventral length (mx, fig. 12). At its inner margin a strong sclerotized arm arises (y, figs. 3, 4). This rod extends to a position lateral to the dorsal edge of the labial prementum. At this point the arm of the maxilla articulates with another sclerotized rod (z) which extends upward from a point just lateral to the attachment of the prementum with the maxillary segment. At the dorsal articulatory point of these two structures, a small apodeme from the maxillary arm extends posteriorly (amxm, figs. 3, 4). Upon this apodeme is inserted the maxillary muscle of Cook (1944b). The maxillary muscle (mxm, figs. 4, 11, 12) originates on the ventral cranial wall just below and mesad to the posterior tentorial pits. According to Cook (1944b), the apodeme acts as a lever to increase the strength of the maxillary muscle.

The other muscle of the maxilla, described as the cranial flexor of the stipes by Cook (1944b), originates on the latero-ventral portion of the ocular lobe (cs, figs. 2, 4), between the two diverging bundles of the mandibular abductor muscle (mab) and posterior to the larval eye (le.) It is inserted on the inner dorsal face of the maxilla.

The palpus is attached to the maxilla on the outer margin of the latter. It is also supported by the mandibular arm (ma, figs. 3, 4) which was described above. There are no muscles inserted on the palpus and its movement is dependent upon that of the maxilla and, to some extent, that of the mandible.

*The Labium:* The labium is composed of several parts whose homologies are extremely confusing. Ventrally, the maxillary plate (mxpl), an extension of the maxillary segment (Cook, 1944b) overhangs the labial structures (figs. 2, 7, 12). The maxillary plate has received several names. Meinert (1886) calls it the "scutum of the second metamere," while Raschke (1887) terms it the mentum or "*Kinn*." Imms (1907) defines this structure as the submentum, while Howard, Dyar, and Knab (1912) call both the maxillary plate and what is probably the true mentum "excrescences of the mentum."

The labium is made up of three, or possibly four parts. Just within the maxillary plate (mxpl) is a toothed projection which, in this species, bears one central spine and six lateral spines on either side. This structure (smt, fig. 14) has been called the aulaeum by Cook (1944b), and is considered to be the submentum by most workers. Dorsal to the submentum is a heavily sclerotized, toothed plate, known as the mentum. In *Anopheles quadrimaculatus*, the mentum (mt, fig. 10) bears four lateral spines on each side of a larger central tooth. According to Cook (1944b), the submentum or aulaeum is present only in the Culi-

cidae while the mentum is present in many other Dipterous larvae. He also states that when reduction of parts takes place in the labium, the submentum is the more stable, while the mentum is lost. He concludes that it is possible that the aulacum is merely a secondary development of a fold between the maxillary plate and what, in this event, would be the true submentum (described above as the mentum).

Dorsal to the mentum and resting in a position perpendicular to the longitudinal axis of the body is the heavily sclerotized prementum (pmt, figs. 8, 16). Just ventral to the prementum is a series of small toothed structures (figs. 8, 15, 16). These consist of a heart-shaped flap (fig. 15) located above the mentum and arising from the base of the prementum. The flap is bounded ventrally by a series of jagged, transparent, sclerotized teeth (fig. 15). Above the heart-shaped flap arises a slender leaflike structure toothed on its distal end (fig. 15).

Just dorsal to the latter is the prementum itself (pmt, figs. 8, 16). Along its median line arise a series of heavy teeth. Placed laterally to these are many smaller tooth-like spines. Ventrally and just above the leaflike structure mentioned above, the central portion of the prementum swings downward in a median projection. On either side of this projection is a roughly circular, more membranous area. This area bears four blunt tapering spines on each side of the median projection (figs. 8, 15).

The entire prementum is square in shape and is bounded by heavily sclerotized bars. On the median posterior aspect of the bars supporting the prementum laterally, are inserted the labial adductor muscles. These muscles (lm, figs. 11, 16) originate on the cranium just beneath the maxillary muscles.

The orifice of the common salivary duct (sd, figs. 8, 11, 16) is located on the anterior and most dorsal aspect of the prementum which has been termed the hypopharynx by some authors (Johannsen, 1903; Imms, 1907).

*The Pharynx:* The pharynx of the mosquito larva is a very peculiar pouch-like structure. Its position within the head (figs. 7, 9) is somewhat oblique to the longitudinal axis of the body. It is an oval structure whose curving lateral margins are sclerotized both dorsally and ventrally, while the middle regions are membranous. The arching borders of the pharynx were called the "crests" of the pharynx by Thompson (1905), and "the elliptical flat ring" by Johannsen (1903). The lateral sclerotization of the external pharyngeal wall (lp, fig. 13) is formed by three concentric rings or bars (ra, rb, rc) in the cuticula which extend dorsally. The dorsal terminations of these bars on either side are connected by the median membranous portion (dp) of the pharynx (figs. 9, 13). Within the pharyngeal cavity itself, two rows of bristles extend into the lumen. These bristles (f, fig. 17) originate on the second and inner of the concentric bars (rb, rc) mentioned above.

Laterally the sclerotized edges of the pharynx are articulated to the cibarial bar (cb) by two curving, somewhat U-shaped structures (u, fig. 13). The dorsal membranous wall of the pharynx is continuous with the dorsal wall of the cibarial cavity (figs. 7, 9). The ventral wall is attached to the prementum (pmt) just dorsal to the opening of the salivary duct (sd, fig. 7).

The internal fimbriae, or setae, found in the pharyngeal cavity were first described by Raschke (1887) who thought they represented a straining apparatus. Johannsen (1903) mentions these bristles and considers that they are a sieve-like mechanism. They are also described by Imms (1907). Cook (1944b) compares the pharyngeal mechanism of several larvae, and figures the bristles in *Theobaldia incidens*, *Armigeres malayi*, and *Anopheles maculipennis*.

The musculature of the pharynx of *Anopheles quadrimaculatus* closely corresponds to Cook's (1944b) findings in other mosquito larvae. Originating on the anterolateral margins of the clypeus are the four pairs of cibarial muscles. These muscles (cm, figs. 1, 9) are inserted fanwise on the dorsal anterior portion of the pharynx, and on the dorsal posterior margin of the roof of the cibarial cavity. The cibarial muscles function to dilate the preoral cavity and the mouth.

The four intrinsic pharyngeal muscles (ip, figs. 9, 13) connect the curving lateral sclerotizations of the pharynx. The two pairs of lateral pharyngeal muscles (lpm, figs. 9, 13) originate on the clypeus near the clypeofrontal suture and are inserted on the lateral margins of the pharynx. The two median pharyngeal muscles (mpm, figs. 9, 13) are inserted on the mid-dorsal posterior portion of the pharynx and extend upward to the clypeus.

There are two pairs of posterior pharyngeal muscles (ppm, figs. 7, 9, 13). The first pair originate on the posterior lateral area of the clypeus. These cross over each other to insert at the margin of the pharynx on the opposite side to their respective points of origin. The second pair are inserted on the dorsal margin of the pharynx and extend to the median posterior wall of the clypeus. These muscles were described in full, under different names by Imms (1907) in his paper on *Anopheles maculipennis*.

The action of the intrinsic muscles, aided by the first pair of posterior pharyngeal muscles, causes the pharynx to be folded together and the lateral sclerotizations to approximate. By this contraction, the food is forced backwards into the oesophagus.

The oesophagus (oe, fig. 7) continues posteriorly from the ventral side of the median pharyngeal area. The ventral pharyngeal muscle holds the oesophagus firmly in place. This muscle (vp, fig. 7) originates on the ventral cranial wall and is inserted on the anterior oesophagus beneath the circumoesophageal commissure.

The details of the central nervous system have not been included in the figures, although the supraoesophageal (b) and frontal (fg) ganglia are indicated (fig. 9).

#### CONCLUSIONS

A detailed study of the morphology of the fourth stage larval head of *Anopheles quadrimaculatus* has been presented. The morphology of this larval head closely tallies with that of *Anopheles maculipennis*. There appear to be only a few points of difference between the two species.

*Anopheles quadrimaculatus* differs from the latter species in the following ways:

The median pharyngeal muscle, not described by Cook (1944b), is present and well developed.

There are present four pairs of cibarial muscles inserted on the dorsal aspect of the pharynx and preoral cavity in the mosquito larva here discussed, whereas Cook (1944b) figures only three pairs in his illustrations of *Anopheles maculipennis*.

The intrinsic pharyngeal muscles of the larva of *Anopheles quadrimaculatus* are differently spaced. The most posterior pair of intrinsic muscles are rather widely separated, while the anterior pair are set very close together (fig. 13). The opposite situation is apparently true in the case of *Anopheles maculipennis*, as here the posterior pair are contiguous and the anterior pair are more widely spaced.

The adductor and abductor mandibular muscles of *Anopheles maculipennis*, as figured by Cook (1944b), are divided into a different arrangement of bundles. Both sets are shown attached to the dorso-lateral margin of the head. In the larva of *Anopheles quadrimaculatus*, the abductor muscle is clearly divided into two large diverging bundles, one of which originates ventrally. The adductor muscle of this species is separated into four bundles, the largest of which also originates more ventrally on the cranium.

Finally, Cook (1944b) considers that both pairs of messorial muscles are inserted on the messores. Only the inner muscles are attached to the messores in larvae of *Anopheles quadrimaculatus*. The outer pair are definitely inserted on the lateral tips of the posterior palatal bar. It is here believed that this discrepancy between the two species is due to an error in observation on Cook's part.

Other points of general morphological interest concerning the larva here considered are listed in the following summary.

The labium is greatly reduced and is made up of three peculiar and highly specialized parts: the submentum, the mentum, and the prementum. The homologies of these structures are not clear.

The orifice of the salivary duct is located on the dorsal margin of the prementum.

The pharynx is an unusual pouch-like organ, supported laterally by three arching, sclerotized rings which are attached to the cibarial bars by U-shaped sclerites. The two inner sclerotized rings each bear internally a row of stiff setae which extend into the pharyngeal cavity and function as a straining mechanism.

It is believed that a convincing theory which accounts for the movement of the labral brushes has been presented and this agrees with the work of Becker (1938).

The paraclypeal phragma is invaginated along the anterior portion of the clypeofrontal suture. From it arises the anterior tentorial arm.

The cibarial bar is strongly developed in this species and extends from the inner edge of the anterior tentorial arm to the prementum, thus bounding the preoral cavity ventrally. The cibarial bar also carries the anterior articulation of the mandible.

The mandible has developed an elongate sclerotized arm which articulates with the ventral cranial wall. This arm also passes around the base of the maxillary palpus and supports the latter structure.

The maxilla is greatly reduced and is composed of the stipes and the palpus. All other maxillary components appear to have been lost.

Up to the present time, papers concerned with the morphology of larval Culicidae have dealt with only a few selected forms. It is probable that a more extended study covering a large number of different species will bring more direct evidence to bear on the homologies of some structures of the head which are now in question.

## LIST OF ABBREVIATIONS

- a—antenna.  
 aam—anterior articulation of the mandible.  
 aem—apodeme of the external messorial muscle.  
 af—antennal foramen.  
 aim—apodeme of the internal messorial muscle.  
 am—antennal muscle.  
 amab—apodeme of mandibular abductor muscle.  
 amxm—apodeme of maxillary muscle.  
 ata—anterior tentorial arm.  
  
 b—brain, or supraesophageal ganglion.  
 blb—base of labral brush.  
  
 cb—cibarial bar.  
 cfs—clypeofrontal suture.  
 cl—clypeus.  
 cls—clypeolabral suture.  
 cm—cibarial muscles.  
 cs—cranial flexor muscle of the stipes.  
  
 dp—dorsal wall of the pharynx.  
  
 em—external messorial muscle.  
  
 f—fimbriae extending into the pharyngeal cavity.  
 fg—frontal ganglion.  
  
 ie—primordia of imaginal eye.  
 im—internal messorial muscle.  
 ip—intrinsic muscles of the pharynx.  
  
 lb—lateral mouth brush.  
 le—larval eye.  
 lm—labial adductor muscle.  
 lp—lateral sclerotization of the pharynx.  
 lpm—lateral pharyngeal muscle.  
 lpp—lateral palatal plate.  
  
 m—mandible.  
 ma—mandibular arm.  
 mab—mandibular abductor muscle.  
 mad—mandibular adductor muscle.  
 mb—median bristles.  
 mes—messor.  
  
 ml—median lobe.  
 mma—median membranous area of the labrum.  
 mpa—median palatal muscle.  
 mpm—median pharyngeal muscle.  
 ms—median ventral suture.  
 mt—mentum.  
 mx—maxilla.  
 mxm—maxillary muscle.  
 mxp—maxillary palpus.  
 mxpl—maxillary plate.  
  
 oe—oesophagus.  
 ol—ocular lobe.  
  
 p—palatum.  
 pab—postantennal buttress.  
 pam—posterior articulation of the mandible.  
 pms—premaxillary suture.  
 pmt—prementum.  
 pp—paraclypeal phragma.  
 ppb—posterior palatal bar.  
 ppm—posterior pharyngeal muscle.  
 pta—posterior tentorial arm.  
 ptp—posterior tentorial pit.  
  
 ra—external sclerotized pharyngeal ring.  
 rb—median sclerotized pharyngeal ring.  
 rc—inner sclerotized pharyngeal ring.  
  
 sd—salivary duct.  
 sl—sclerotized portion of the labrum.  
 smt—submentum.  
 so—salivary duct orifice.  
  
 ta—triangular sclerite of posterior palatal bar.  
 tg—transverse girdle.  
  
 u—U-shaped sclerite of the pharynx.  
  
 va—ventral anterior wall of the head.  
 vp—ventral pharyngeal muscle.  
  
 y—sclerotized arm of the maxilla.  
  
 z—sclerotized rod lateral to the prementum.



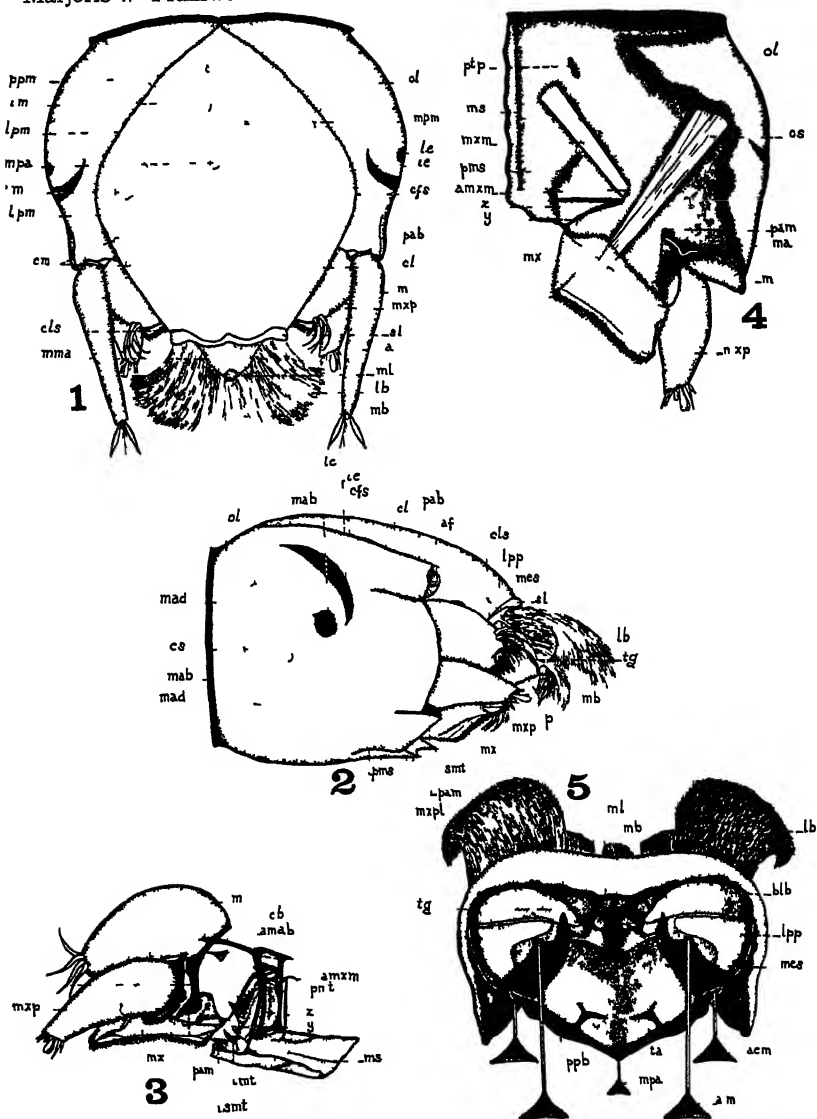
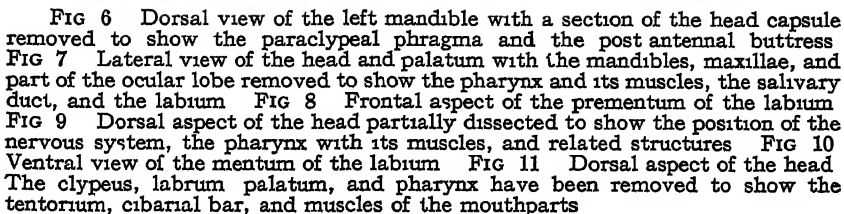


FIG 1 Dorsal external view of the head The dotted circles indicate the origins of muscles on the clypeus FIG 2 Lateral external view of the head The dotted circles indicate the origins of muscles on the ocular lobe FIG 3 Lateral oblique view of the mandible, maxilla, and labrum illustrating the apodeme of the maxillary muscle and the mandibular arm supporting the maxillary palpus FIG 4 Dorsal internal view of the left maxilla with its palpus showing the origin and insertion of the cranial flexor muscle of the stipes, and the attachment of the mandibular arm to the ventral cranial wall FIG 5. Internal view looking anteriorly into the labrum and palatum to illustrate the transverse girdle, lateral palatal plates, messorres, and posterior palatal bar



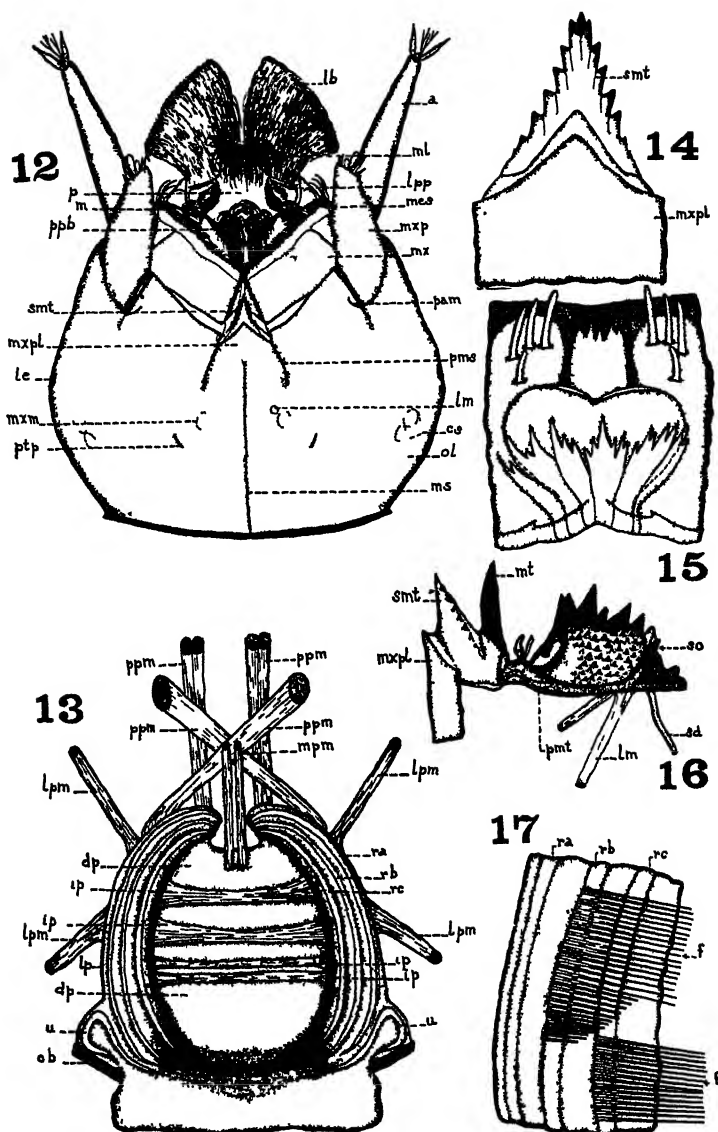


FIG. 12. Ventral external view of the head. The dotted circles indicate the origins of muscles on the head capsule. FIG. 13. Dorsal detailed view of the pharynx and its muscles. FIG. 14. Ventral view of the maxillary plate and the submentum of the labium. FIG. 15. Detailed view of the heart-shaped flap and associated structures of the prementum. FIG. 16. Lateral view of the maxillary plate, submentum, mentum, and prementum of the labium. FIG. 17. Internal view of a section of the lateral sclerotization of the pharynx illustrating the two rows of fimbriae extending into the pharyngeal cavity.

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# THE SIGNIFICANCE OF THE "EDITORIAL NOTES" IN THE REPRINTS OF THE EARLIER OPINIONS ON ZOOLOGICAL NOMENCLATURE

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Opinions of the International Commission on Zoological Nomenclature, beginning with Number 1, are being reprinted with "Editorial Notes" by Secretary Hemming. Certain of these notes are factual and historical in nature; others are interpretations, and as such they may be open to difference of opinion. For example—

(1) Opinion 1 (reprint), pp. 78-79.—The second of two names in the usual scientific name is to be called the "trivial name" and not the "specific name." The Commission's own use of the expression "specific name" in the summary of Opinion 1 is characterized as "loose." Yet the expression is used in that same "loose" sense in Articles 11 to 18 inclusive, 23, 25, and 32 of the Code itself, and in summaries of Opinions 1, 12, 13, 64, 70, 97, 128, and 134, as well as in numerous places in the discussions of the Opinions. Was the Commission then consistently "loose," or is that really the way it intended the expression "specific name" to be used?

(2) Opinion 6 (reprint), p. 131, footnote 9.—The Secretary's interpretation appears to be that a verbal statement of type designation is necessary for a monotypic genus to fulfill the requirements of Article 25 as amended in 1927 (requiring a "definite and unambiguous designation of the type species"). Yet in the view of Stiles and Stejneger, and of Dautzenberg (paragraphs 7 and 8, p. 131), "If a genus is monotypic, this is *ipso facto* designation of the most definite kind." And certainly unambiguous! Is there any reason to believe that a genus published with only one included species (monotypic), although this is not stated to be the type, is not valid under Article 25, even as amended? Was not the amendment intended to supplant only section II (on subsequent designation) of Article 30, after December 31, 1930?

(3) Opinion 6 (reprint), Editorial Note 3 (italics are mine).—The Secretary maintains that "The wording employed in Opinion 6 is *absolutely unambiguous* and leaves no loophole for misunderstanding as to the meaning or scope of the Commission's decision." He further states that the account of the discussion, in paragraph 2 of the Opinion, "makes it *absolutely clear* that the question then put to, and answered by, the members of the Commission was the *strictly limited* question then laid before the meeting in the form of a diagram."

It is true that the title of the Opinion mentions a genus with *two* species, as does the summary. Paragraph 2, however, states that "the position of the Commission upon cases of this kind was asked, and the reply was made by all members of the Commission who were present

that cases which were as clear as the one given in the diagram should be construed under Article 30 (g), namely, that the type of the original genus was fixed when, through a division of its species, it was definitely made into a monotypic genus."

It seems reasonable to infer that the consensus of the Commission was that any such *clear-cut* case would be treated in like manner, even though it involved more than two species. Would it not have been an equally *clear* case had the genus A\_\_\_\_\_ contained *three* species, A\_\_\_\_\_ b\_\_\_\_\_, A\_\_\_\_\_ c\_\_\_\_\_ and A\_\_\_\_\_ d\_\_\_\_\_, with a later author removing A\_\_\_\_\_ c\_\_\_\_\_ and A\_\_\_\_\_ d\_\_\_\_\_ to a new genus or to two new genera, leaving genus A\_\_\_\_\_ with one species, b\_\_\_\_\_, and hence monotypic?

Whether the individual reader agrees or disagrees with the views expressed in the above examples is immaterial at this time. The essential point is that these footnotes and editorial notes have the appearance of formality and may be accepted by some at face value as a part of the respective Opinions. However, it should be clearly understood (and this ought to be definitely stated in any such notes that accompany reissued Opinions) that these comments are not necessarily the *Opinion* of the Commission as a whole, have not been voted on or approved by the Commission, and cannot and do not share the force of the original Opinion. In any problems where more than one interpretation is possible, the case cannot legitimately be decided by these notes alone.

MAN THE ANIMAL, by RAYMOND PEARL. 128 pages. 1946. The Principia Press, Bloomington, Indiana. Price \$2.50.

In the reviewer's opinion Doctor Pearl was the most comprehensive and penetrating analyst of our own species that the biological profession has produced in the twentieth century. That opinion is a confession of close agreement with his conclusions and also a forecast of enthusiasm for his small posthumous volume.

*Man the Animal* includes the five Patten Foundation Lectures delivered at Indiana University in October, 1938. According to the foreword it was his intention to expand the lectures before publication but when he died on November 17, 1940, the work had not been done. His manuscript was prepared by Mrs. Pearl with the help of some of his friends and is now presented in book form. Even though it is not as he would have completed it, the book is a monument to the fine intelligence of the writer in applying to mankind the biological knowledge which should long ago have given us better understanding of ourselves and a sounder solution of human problems than other approaches have provided.

Dr. Pearl's first two lectures deal with man as the unique mammal. The first considers matters that are more or less common knowledge among biologists. The relation of man to the anthropoid apes and the nature of his primate ancestry are treated briefly and with them the essential distinctions of upright posture, large brain, articulate speech and longer life span, of which the last is not discussed in detail. The first three are fundamentally related in providing man with essential tools, his hands, with the ability to use them effectively, and with the means of communicating and perpetuating his discoveries. A discussion of his far-reaching attainments in supplementing his biological adaptations with tools in the broad sense of the word concludes the lecture. "All useful machines," the author says, "are additions to the biological equipment of man as an animal. Some are additions to his motor powers; others to his sensory. But their fundamental meaning is always biological. Except as a part of man's biological equipment they have no significance."

In the second lecture the role of this peculiar ability in providing man with the elaborate environment of civilization is discussed in some detail, with a final blunt comment on the human claim of rational conduct: "But really only a small fraction of his behavior is rational. The rest is just mammalian, or of still lower evolutionary order." The lecture concludes with a discussion of the fundamental relationship of all kinds of human beings and brief mention of the proposals for regulating the nature of men, ending in a promise later to consider whether "turning man, the unique mammal, into man, the contented cow" is really the most desirable goal.

Lecture three also deals with matters more commonly known to biologists, or at least to those who have given some thought to our population problems. It considers chiefly our success in increasing life expectancy and the resulting change in age distribution in the population.

*The Numbers of Men* as a title for the fourth lecture scarcely conveys the tremendous implications of the facts concerning the increase of numbers which are discussed in it. During the three centuries for which dependable estimates or accurate data are available, the human species has increased at an almost incredible rate. The author cites H. L. Hawkins' statement that no species has ever yet been able to adapt itself swiftly and skilfully enough to survive such circumstances, and concludes that man's hope of ultimate success rests on "the fact that he has shown himself on occasions to possess somewhat greater innate powers of adaptability than any other organism has known. One wonders at this point what Doctor Pearl would have said of the capacity of the tool-making, talking creature to adapt himself through those powers without bodily change.

The concluding lecture, *Patterns for Living Together*, expresses the thoughts which the author published in an article with the same title in *Harper's Magazine* a year or two after the lectures were delivered. It brings out the essential contrast between the perfect regimentation of the insect society and the individualism of man which is his heritage as a mammal and cannot be completely subordinated to the demands of his social organization, and emphasizes as the price of success in social groups the encouragement of individuals to express their own peculiar talents.

The reviewer's thoughts have led him through a decade to conclusions very like those of Doctor Pearl. This agreement may be merely a basis of approval. On the other hand, conclusions drawn independently from complex data imply by their agreement a fundamental soundness that cannot lightly be dismissed. One cannot hope that a book of this kind will be widely read, particularly by the politicians and labor leaders and industrialists who ought to read it, but it is not exaggeration to say that it strikes at the root of human difficulties and could well be a guide to their solution.—A. W. L.

# THE ENTOMOLOGICAL SOCIETY OF AMERICA

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## PROCEEDINGS OF THE FORTY-FIRST ANNUAL MEETING

Richmond, Virginia, December 9-12, 1946

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The Entomological Society of America held its forty-first annual meeting Monday through Thursday, December 9-12, 1946, in conjunction with the annual meeting of the American Association of Economic Entomologists, the Headquarters for the joint meeting being in the John Marshall Hotel, Richmond, Virginia. Attendance for the joint meeting was over 400 and about 300 attended the Entomologists' Banquet.

Monday, Tuesday and Wednesday mornings, the two societies held a joint session, and in the afternoon broke up into individual sessions of the two societies. Monday evening was featured by the annual public address of the Entomological Society of America, and on Tuesday evening the Entomologists' Banquet was held with a guest speaker. The program presented at the four-day meeting follows:

### Monday Morning, December 9, 10 A. M.

#### JOINT MEETING WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

President Muesebeck called the session to order and introduced Dr. Clay Lyle, President of the American Association of Economic Entomologists, who delivered his Presidential Address, "Achievements and Possibilities in Pest Eradication."

At the end of the joint session, the Executive Committee of the Entomological Society held a preliminary meeting.

### Monday Afternoon, December 9, 1:30 P. M.

President Muesebeck called the session to order and announced the appointment of the following committees:

*Nominating Committee*—W. E. HOFFMAN, S. W. FROST, R. E. SNODGRASS, Chairman.

*Resolutions Committee*—H. L. SWEETMAN, F. W. POOS, Z. P. METCALF, Chairman.

The following papers were presented:

1. The insect cranium and its so-called "sutures" (25 min., illus.), R. E. SNODGRASS, Washington, D. C.
2. Further notes on the behavior of burying beetles (*Nicrophorus* spp.), by title), L. J. MILNE, University of Pennsylvania.
3. The larvae of *Pleocomma* and its systematic position (Coleoptera, Pleocomidae) (10 min., illus.), W. P. HAYES and PEI-I CHANG, University of Illinois.
4. The classification of Coleoptera (20 min.), J. CHESTER BRADLEY, Cornell University.



5. Apicoterme Nests: A remarkable case of behavior evolution (by title), ALFRED E. EMERSON, University of Chicago.
6. Mathematics and Biology, W. R. THOMPSON, Belleville, Ontario, Canada.
7. The flight of the Drone fly (20 min, illus.), C. H. CURRAN, American Museum of Natural History.

### Monday Evening, December 9, 8 P. M.

Dr. Frank M. Carpenter, Harvard University, presented the Annual Public Address entitled, "Early Insect Life," illustrated with slide material.

### Tuesday Morning, December 10, 9:30 A. M.

#### JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

President Lyle called the meeting to order and introduced the speakers on the first part of the program:

An entomological survey of the Micronesian Islands, by H. K. Townes and R. G. Oakley, B. E. P. Q.

After discussion on this part of the program, President Lyle turned the program over to J. F. Yeager for the latter part of the program: Insect Physiological Research in Relation to DDT and Other New Insecticides.

Excellent informal discussions of their investigations were presented by Dr. Kenneth D. Roeder, Department of Biology, Tufts College, Massachusetts; Dr. Julian M. Tobias, Department of Physiology and the Toxicity Laboratory, University of Chicago, Illinois, and Dr. Leigh E. Chadwick, Medical Division, Edgewood Arsenal, Maryland. This program was completed in the early afternoon with an interesting discussion by Dr. Daniel Ludwig, Department of Biology, University Heights, New York University. In the afternoon, formal papers on insect physiology were presented at the Physiological Section. A widespread interest in insect physiological work was manifested by the entomologists at both of these sessions.

### Tuesday Afternoon, December 10, 1:30 P. M.

Presentation of papers, Physiological Section: J. F. YEAGER, B. E. P. Q., presiding.

8. Electron microscope studies of the structure of isolated cuticular membranes in relation to their use in permeability studies (15 min., illus.), A. GLENN RICHARDS, University of Minnesota.
9. A preparation for the study of factors affecting synaptic transmission in the central nervous system of the cockroach (15 min., illus.), KENNETH D. ROEDER, Tufts College.
10. Certain biochemical changes in the DDT poisoned insect (15 min.), JULIAN M. TOBIAS, University of Chicago.
11. Blood volume in the roach, *Periplaneta americana*, determined by several methods (15 min., illus.), J. FRANKLIN YEAGER and SAM C. MUNSON, B. E. P. Q.
12. Blood volume and chloride level in the roach, *Periplaneta americana*, injected with NaCl solutions (15 min., illus.), SAM C. MUNSON and J. FRANKLIN YEAGER, B. E. P. Q.
13. The effect of peanut oil on the desiccation of *Promethia* pupae (10 min., illus.), DANIEL LUDWIG, New York University.

**Tuesday, Evening, December 10, 6:30 P. M.**

The Entomological Banquet was held in the Virginia Room with an attendance of about 300. At the end of the banquet, J. van der Vecht, Instituut voor Plantenzieken, Buitenzorg, Java, gave a most interesting address, "War Experiences of an Entomologist in the Far East."

**Wednesday Morning, December 11, 9:30 A. M.****JOINT SESSION WITH AMERICAN ASSOCIATION OF  
ECONOMIC ENTOMOLOGISTS**

A discussion of the United Nations Educational Scientific, and Cultural Organization (UNESCO), DETLEV W. BRONK, Philadelphia, Pennsylvania.

Preventive Entomology, P. N. ANNAND, B. R. P. Q.

The proposed revision of the Federal Insecticide Act and the need for uniform state legislation, W. G. REED, U. S. D. A., P. M. A.

**Wednesday Afternoon, December 11, 1:30 P. M.**

Presentation of papers, continued:

14. Tarsal chemoreceptors of the house fly and their possible relation to DDT toxicity (15 min., illus.), W. P. HAYES and YU-SU LIU, University of Illinois.
15. A review of the genus *Atricholaelaps* Ewing, a group of mites parasitic chiefly on rodents (Acarina: Laelaptidae), (15 min., illus.), B. W. STRANDTMANN, University of Texas.
16. Notes on *Melanoplus mexicanus*, its included subspecific units, and related species (15 min., illus.), ASHLEY B. GURNEY, B. E. P. Q.
17. Plastics and standardization technique reform Lepidoptera collections (by title), OTTO ACKERMANN, Irwin, Pennsylvania.
18. Revision of the Naucorid Subfamily Cryphocircinae (15 min., by title), ROBERT L. USINGER, University of California.
19. Review of generic concepts in Corixidae (by title), H. B. HUNGERFORD, University of Kansas.
20. Some new species of Delphacine Fulgorids (by title), R. H. BEAMER, University of Kansas.

**Wednesday Afternoon, December 11, 3 P. M.**

At the end of this program President Muesebeck opened the annual business meeting of the Society which is reported here at the end of the Presentation program.

**Thursday Morning, December 12, 10 A. M.**

Discussion section on problems in systematics and nomenclature. This program was planned by R. L. Usinger, University of California, but Dr. Usinger was unable to attend the meeting. In his absence C. W. Sabrosky, B. E. P. Q., presided.

To open the discussion, Dr. A. B. Gurney outlined the problem of the specific units of *Melanoplus mexicanus* and its allies, and President Muesebeck presented a discussion prepared by L. L. Buchanan (who was unable to attend the meeting) on speciation problems in parthenogenetic weevils, especially in the white fringed weevil complex. Discussion on these two papers and ramifications which they suggested continued throughout the session. At its close President Muesebeck adjourned the session and the annual meeting.

Wednesday Afternoon, December 11, 3 P. M.

ANNUAL BUSINESS MEETING OF THE SOCIETY

The meeting was called to order by President Muesebeck and the following business was transacted:

REPORT OF THE SECRETARY

*Executive Committee Activities:*

The activities of the Executive Committee during the year have already been published in the September, 1946, number of the *ANNALS*, page 341. Since the time of that report, the Executive Committee has been concerned primarily with planning for the annual meeting. As the time for these approached, a tide of complaints was received from Society members in teaching positions, requesting that every effort be made to hold future meetings during the Christmas recess.

*Annual Executive Committee Meeting:*

The Executive Committee convened in the John Marshall Hotel for its first session at 11:30 A. M., December 9, and for a later session at 9:30 P. M., December 10. The following members were present: C. F. W. MUESEBECK, H. H. ROSS, S. A. GRAHAM, A. W. LINDSEY, and S. W. FROST. PRESIDENT MUESEBECK designated the following alternates who were also present: Z. P. METCALF, D. M. DELONG, J. C. BRADLEY, and S. W. BROMLEY.

1. Twenty-seven new members were elected as members of the Society, listed in the Section of New Members. The following have resigned during the year: THOMAS GLENN BOWERY, EDWARD L. COMAN, ROBERT H. COOPER, BRUCE D. GLEISSNER, RICHARD H. HANDFORD, NORMA LEVEQUE, ISABEL MCCracken, A. C. MAXSON, ROY H. NAGEL, JOHN C. PRITCHETT, EUGENE M. STAFFORD, and ROBERT A. WARDLE.

2. The following have been automatically dropped as members either because of failure for three or more years to pay dues, or because they cannot be reached: E. J. EPSTEIN, KENNETH GOGEL, I. M. HAWLEY, J. F. T. JODKE, L. C. PETTIT, and G. S. STAINS.

3. The following were elected as Fellows of the Society: F. S. BLANTON, J. S. CALDWELL, H. O. DEAY, P. B. DOWDEN, W. D. FIELD, W. D. MURRAY, C. T. PARSONS, H. D. PRATT, CHARLES SEEVERS, FRANK SHAW, V. M. TANNER, E. S. THOMAS, and H. M. TIETZ.

4. In recognition of his lifetime of service to the Entomological Fraternity and the high quality and constancy of his work, it was moved and seconded that PROFESSOR C. T. BRUES be elected an Honorary Fellow of the Society. Motion carried unanimously.

5. The Society has suffered the loss by death of the following six members. FRANK E. BLAISDELL, GRACE H. GRISWOLD, T. J. HEADLEE, R. H. PETTIT, JOSEPH R. WATSON, and ROSWELL C. WILLIAMS, JR. Following the announcement of these losses to the Society, the members stood in silence in honor of the memory of those who have died in the last year.

6. The following were elected to fill the three vacancies of the Editorial Board: D. J. BORROR, PHILIP GARMAN, and F. H. BUTT. These will serve through 1949.

7. To fill the two vacancies in the Thomas Say Foundation for a period of two years, C. F. W. MUESEBECK and HERBERT H. ROSS were renominated and elected.

8. TIME OF ANNUAL MEETING—In consideration of the fact that some of the uncertainties seem to have been removed regarding transportation and accommodations which existed during the war, it seems feasible to make more definite plans for future meetings of the Society. Dr. Cory, Secretary of the American Association of Economic Entomologists, suggested to your President and Secretary that an effort might be made to have a program somewhat similar to that which was being followed prior to the war and invited the two officers to join an Executive Committee meeting of the A.A.E.E. to discuss such a program.

The following plan was adopted at that meeting as a working basis for future annual meetings, as follows:

1. In consideration of the fact that the members of the two societies having teaching commitments find any time other than the Christmas vacation is a very difficult time to attend the meetings, it was decided to hold them in the future during the Christmas-New Year vacation period.

2. Many members want to meet with the American Association for the Advancement of Science but on the other hand the A.A.A.S. plans to schedule its meetings chiefly or entirely in the northeastern quarter of the country, which is very undesirable from the standpoint of giving impartial service to membership of the two entomological societies. In order to attempt a balance between these two, the following long term schedule is offered for consideration:

1947—Chicago with the A.A.A.S.

1948—New York with the A.A.A.S.

1949—In the South (Jacksonville, Atlanta, New Orleans).

1950—In the West (Kansas City, Denver, Omaha, Des Moines, Salt Lake City).

1951—In the Mid-West (hoping that the A.A.A.S. will meet in this area and being governed by their choice of city—possibly Columbus, Cleveland, Cincinnati or Indianapolis).

1952—In the East again hoping that the A.A.A.S. will meet in the East. (If the A.A.A.S. decides on the East in 1951 and the mid-west in 1952, we should reverse this schedule for 1951 and 1952.)

1953—West Coast—Los Angeles, San Francisco, Seattle.

1954—In the North (possibly a Canadian City, Boston or Buffalo (there is of course the possibility that the A.A.A.S. will be meeting in this area)).

1955—In the Southwest (San Antonio, Houston, Dallas or Fort Worth).

As stated by Dr. Cory, "This schedule is flexible as to exact place, provides for at least four meetings with the A.A.A.S., coinciding with their meeting time, and provides that every area in the U. S. may be adequately served. If circumstances that develop determine that it is unwise to go south in 1949, it would be possible and practical to interchange in 1949 and 1950. This also gives local groups a chance to plan a long time ahead in order to make their meeting a success. For instance, the west coast entomologists can determine in which city they want to hold the meeting and then prepare long in advance to make a success of their meeting."

After considerable discussion, the Executive Committee approved this recommendation but added that they did not believe that the dates should be made too definite, depending on circumstances at the time.

9. At this point was brought up the matter concerning a joint committee to prepare a history of entomology in the war effort, as recommended in last year's report of the joint committee on Coordination of Entomology with the War Effort. Following this recommendation it was moved and seconded that the President appoint two members of such a committee to work with two members to be appointed by the A.A.E.E., the committee to choose its own Chairman. Motion carried.

10. Considerable discussion was given to the petition of Joseph W. Enke regarding the role of the Entomological Society in cooperating or directing army and navy work in entomology. It was decided to appoint a special committee to study the possibilities of facilitating entomological activities in cooperation with the army and navy along the lines of proposals 2 and 3 of the petition of Mr. Enke.

11. It was voted to contribute \$100.00 to the support of Zoological Record.

12. It was voted to make a contribution of \$50.00 to the International Commission of Entomological Nomenclature for the express purpose of aiding the publication of the Bulletin of Zoological Nomenclature.

13. It was voted to continue the current arrangement for the support of the American Committee on Entomological Nomenclature.

Respectfully submitted,

HERBERT H. ROSS, *Secretary.*

There followed additional explanation of the arrangements regarding the future meeting dates. DR. FRACKER requested that consideration be given to meeting with the Phytopathologists during the odd years when the Society did not meet with the A.A.A.S. Following this it was moved and seconded that the Secretary's report be accepted as read. Motion carried.

PRESIDENT MUESEBECK then appointed the committees called for by the adoption of the Secretary's Report. He appointed H. M. HARRIS and F. C. BISHOPP, *Chairman*, a special committee to study the Enke report, and S. W. BROMLEY and P. W. OMAN to serve on the joint committee of two regarding the history of entomology in the war.

### TREASURER'S REPORT

MARCH 14, 1946, TO DECEMBER 1, 1946

#### CURRENT FUND

##### RECEIPTS

Balance on hand March 14, 1946.....	\$3,320.40
Annual dues.....	1,845.00
Total.....	\$5,165.40

##### EXPENDITURES

<i>Annals</i> .....	\$2,500.29
Office expenses, including costs incurred in March meetings.....	155.41
Checks returned.....	5.00
Travel expenses.....	47.56
Zoological Society of London, for Zoological Record.....	100.05
Total.....	\$2,808.31

#### PERMANENT FUND

Balance as of March, 1946.....	\$4,596.23
Liberty Bond.....	50.00
Total.....	\$4,646.23

#### TOTAL RESOURCES OF SOCIETY

Balance in Permanent Fund.....	\$4,646.23
Balance in Current Fund.....	2,357.09
Total.....	\$7,003.32

Respectfully submitted,

HERBERT H. ROSS, *Treasurer*.

It was pointed out that the Society's balance was quite favorable, especially considering the fact that the 1947 dues had not started to come in numbers until after the audit was taken. It was moved and seconded that the Treasurer's report be adopted as read subject to approval of the Auditing Committee. Motion carried.

### REPORT OF THE MANAGING EDITOR

Since the war is over and the undersigned is completing his second year as managing editor of the *Annals*, it would be pleasant to report that everything is going smoothly and efficiently with our journal. Unfortunately it is not yet possible to do so. Among the bright spots are the efficient work of Mrs. Helen

S. Lanman, who continues to handle subscriptions and the mailing list in Columbus, and of Miss Doris Cripps, of the Ohio State University mailing room, who handles our addressograph service. The steady influx of excellent manuscripts is also encouraging.

Since last spring the remainder of the back numbers has been transferred to Granville. An attempt to secure lumber for shelving so that a reasonable stock can be made accessible for filing orders has not been successful to date. Steel shelving would be much more satisfactory, but for the present we have released enough shelving in one of the departmental storerooms at Denison to meet the problem temporarily. This expedient cannot be a final solution; we hope that a few more years will make supplies more available so that the *Annals* stock can be housed in the space originally assigned to it.

The problems of publication are still with us as our members will realize from the extremely late mailing of the September issue, which may not have reached them prior to the annual meeting. The printers are still short-handed and I was told on a recent visit that the supply of paper is still very uncertain. The mills are shipping green paper direct from the machines; their warehouses contain no reserve stock. We have, however, made a satisfying return to the heavier paper which was prohibited during the war. Judging by remarks made to the editor during 1945 this change probably pleases everyone.

We have also made a very satisfactory gain in material for publication. Our accumulated prewar backlog was a great help in maintaining the size of the volumes through the war. It was entirely published, however, and we are now receiving approximately the number of manuscripts needed to publish 700 to 800 pages per year. The editor regards this length as very satisfactory. Whether the *Annals* may later reach the size of prewar volumes will depend on circumstances, but we need offer no apology for its present state. The existing conditions also enable us to publish much more promptly than before the war, often within three months and usually within six months of the receipt of manuscripts.

The editor apologizes again for delay in returning drawings and cuts. As for the latter, the printers' promise to assemble used cuts has not been fulfilled. We hope that it may be possible soon to bring this work up to date and to render more prompt service when that is once done. Since the time given to the *Annals* is considerable and the editor also carries the responsibility of heading the largest science department in Denison University, he has to fit his various duties as well as possible into the available hours.

One change has been made in sales policy during the year. Since the stock of reprints is large and the very limited orders for such material can be filled only at a disproportionate cost in time, this service has been discontinued with the approval of the editorial board. Reprints of separate articles are no longer being received. A proposal to Mr. John D. Sherman, Jr., that he take over the stock on hand on a consignment basis was not accepted. His counter-proposal was that we furnish him a complete inventory and permit him to buy outright the salable items. Even this proposal was accompanied by a time limit that made it impossible to consider. The disposition of this stock must be arranged later.

Financially the affairs of the *Annals* are in excellent condition. The cost of printing has advanced to approximately seven dollars per page, which is still a dollar less than the eastern scientific publishers would charge. This saving, or a large part of it, is probably due to our assumption of editorial work which is handled by such organizations as Williams and Wilkins for many journals. In spite of increased costs, and partly because of the moderate size of the current volume, the *Annals* account shows a cash balance of \$1,501.32 for the ten months since the books were last audited, in contrast with the balance of \$948.85 for the preceding thirteen months. Since the printers' bills are paid by the treasurer these figures do not include the portion of the cost defrayed from membership dues. Neither does the current balance include a considerable sum to be collected from authors for cuts published recently. In all we are decidedly solvent and should be able to care for any reasonable increase in the number of pages per volume in the next year or two without financial strain.

In conclusion, the editor reiterates his feeling that the interests of the society would be served better by having the editorship located in an institution with an entomological staff so that more than one man could be familiar with the duties of the office. As long as health permits, however, he values the opportunity to

carry on the work and wishes to thank the many members who have expressed their appreciation to him. He makes no claim to omnipotence but will carry on to the best of his ability as the pressing duty of earning a living permits.

## FINANCIAL STATEMENT FOR THE PERIOD

February 1 to November 30, 1946

## RECEIPTS

Balance forwarded February 1, 1946.....	\$ 540.30
Balance transferred from Columbus account.....	872.59
Contribution from Dr. William Procter.....	500.00
Received from subscriptions.....	758.00
Sales of back numbers and reprints.....	50.12
Received from authors for cuts.....	303.36
Total.....	<u>\$3,024.37</u>

## DISBURSEMENTS

Terry Engraving Company.....	\$ 416.48
Spahr & Glenn Company for stationery.....	27.71
Spahr & Glenn Company for reprints.....	23.85
Stenographic service.....	180.50
Addressograph service.....	21.50
Postage.....	92.43
Denison University, for telephone and freight charges.....	3.86
Labor, packing back numbers for shipment to Granville.....	6.00
Transferred to the Treasurer.....	750.00
Bank charges.....	.72
Balance in the Peoples State Bank of Granville, November 30.....	1,501.32
Total.....	<u>\$3,024.37</u>

Respectfully submitted,

A. W. LINDSEY, *Managing Editor*.

It was moved and seconded that the report of the Managing Editor be adopted as read subject to approval of the Auditing Committee. Motion carried.

REPORT OF THE EDITOR AND TREASURER OF THE  
THOMAS SAY FOUNDATION

Referring to the reports of The Thomas Say Foundation for 1944 and 1945, one notices that previous to 1944 the publication of the first three volumes was possible only through sales. In 1945, \$2,099.42 was obtained from the late W. S. Blatchley and \$1,000.00 from Dr. Julius Hyman, late President of the Velsicol Corporation. As a result, the Foundation is now able to publish Volume IV.

A manuscript prepared by David G. Hall on the "Blow Flies of North America" has been in the hands of the Foundation for about three years, but it has been impossible to find a suitable publisher who could handle it because of paper and labor shortages. However, a publisher was obtained this summer, but because of further shortages publication has been slow and delayed. The volume should be available in the near future.

The financial report follows:

## RECEIPTS

Balance on hand, March 1, 1946.....	\$3,734.32
1946 sales of Volume I— 3 @ \$3.00.....	9.00
1946 sales of Volume II— 2 @ \$5.00.....	10.00
1946 sales of Volume II— 9 @ \$4.50.....	40.50
1946 sales of Volume III— 3 @ \$4.00.....	12.00
1946 sales of Volume III—14 at \$3.60.....	50.40
Interest to June 30, 1946.....	17.55

Total Receipts.....\$3,873.7

## EXPENDITURES

Express on Manuscript.....	\$ 1.33
Postage.....	4.19
Three sets of electrotypes for Volume IV.....	225.00
Total Expenditures.....	\$ 230.52
Due from 1946 sales.....	\$3,643.25
Balance in Purdue State Bank, December 1, 1946.....	\$ 16.60
	\$3,643.25

Respectfully submitted,

J. J. DAVIS, *Editor and Treasurer.*

It was moved and seconded that the report of the Editor and Treasurer of the Thomas Say Foundation be adopted as read subject to approval of the Auditing Committee. Motion carried.

## REPORT OF THE AUDITING COMMITTEE

We, the undersigned, beg to report that we have examined the accounts of the Treasurer of the Entomological Society of America, the Editor of the *Annals* of the Society, and the Treasurer of the Thomas Say Foundation and have found them to be balanced and correct as of December 1, 1946.

The accounts of the Treasurer, H. H. Ross, were examined by Wm. P. Hayes; those of the Editor, A. W. Lindsey, by R. L. Robb, and those of the Treasurer of the Thomas Say Foundation by George E. Gould.

Respectfully submitted,

GEORGE E. GOULD,  
R. L. ROBB,  
WM. P. HAYES, *Chairman.*

It was moved and seconded that the report of the Auditing Committee be accepted as read. Motion carried.

DR. S. B. FRACKER, who represented the Entomological Society at a meeting called by the National Research Council to consider the projected Institute of American Biologists, gave an informal report on the subject. He said that only preliminary ideas had been formulated as yet but that the National Research Council would undoubtedly proceed with the matter further in the near future.

The subject of DR. DETLEV W. BRONK's morning address on UNESCO was discussed, particularly with the thought that mutual benefits might accrue to UNESCO and the Society by cooperative action. It was moved and seconded "that the Secretary be instructed to contact the Secretary of the American Association of Economic Entomologists and Dr. D. W. Bronk, and work out a procedure for joint representation of the two entomological societies to work with the National Research Council on entomological matters pertaining to UNESCO." Motion carried.

## REPORT OF THE COMMITTEE ON RESOLUTIONS

1. The members of the Entomological Society of America wish to express their appreciation to the Committee for Local Arrangements: P. D. SANDERS, *Chairman*, G. T. FRENCH, R. W. BRUBAKER, W. E. BICKLEY, R. B. ARNOLD, and J. P. VINZANT, and to the officers of the Society for their efforts and successful planning for this meeting in the face of extreme difficulties; to the officers and members of the American Association of Economic Entomologists for their splendid cooperation; and to the members of the Committee on Local Arrangements at Pittsburgh: A. C. MILLER, *Chairman*, H. G. GUY, ARNOLD MALLIS, and G. E. WALLACE, who spent much time and effort in planning for that meeting.





The broader nomenclatural studies initiated by the Committee itself include (1) a study of family names of American Insects, (2) a survey of proposals pending before the International Commission on Zoological Nomenclature with a view to obtaining an expression of Committee opinion on matters pertinent to entomological nomenclature for transmissal to the Secretary of the International Commission, and (3) the preparation of a proposal or series of proposals to the International Commission on Zoological Nomenclature regarding the nomenclature of categories of less than subspecific rank.

The Committee also revised and amended its By-Laws. The revised By-Laws follow:

#### NAME.

1. The name of this Committee shall be the American Committee on Entomological Nomenclature.

#### SPONSORSHIP.

2. The Committee exists under the joint sponsorship of the Entomological Society of America and the American Association of Economic Entomologists, to each of which it shall be equally responsible.

#### OBJECTIVES.

3. The objectives of this Committee shall be:

- a. To initiate or to further action tending to stabilize the nomenclature of American insects.
- b. To make recommendations directly to the International Commission on Zoological Nomenclature or through the International Commission on Entomological Nomenclature on cases involving action of interest to entomologists.
- c. To give advice on problems of nomenclature that may be submitted to the Committee by any American entomologist.

#### LIMITATION.

4. The Committee in all its actions shall be bound by the International Code of Zoological Nomenclature and by the Opinions of the International Commission on Zoological Nomenclature.

#### MEMBERS.

5a. The Committee shall consist of nine members.

5b. Three members shall retire each year but shall be eligible for re-election. The term of office of a retiring member shall end at the close of the Annual Meeting.

5c. At least two names shall be placed in nomination for each vacancy by the Chairman.

5d. Members shall be elected annually by a majority vote of the Committee, but shall be subject to confirmation by the executive committee of each sponsoring organization. The election shall be by mail ballot and shall be completed not less than one month prior to the Annual Meeting.

5e. Ballots for members shall be sent to and tallied by a member of one of the sponsoring organizations to be designated by the chairman

#### OFFICERS.

6a. The officers of the Committee shall be a chairman and a secretary.

6b. It shall be the duty of the chairman to preside at meetings and to initiate any action, including the appointment of subcommittees, looking towards the fulfillment of the objects of the Committee.

6c. It shall be the duty of the secretary to carry on official correspondence, mail ballots, arrange for the preparation of reports and summaries of committee action, render an Annual Report to the Committee for transmission to the two sponsoring organizations, and transact other business.

6d. The officers shall be elected annually by a majority vote of the Committee, the election to be by mail ballot and completed not less than one month prior to the Annual Meeting. Election of a retiring member to office shall be tantamount to re-election to membership on the Committee. Newly elected officers shall take office at the close of the Annual Meeting.

6e. Ballots for officers shall be sent to and tallied by a member of one of the sponsoring organizations to be designated by the chairman.

#### TRANSACTION OF BUSINESS.

7a. The Committee shall be empowered to make such rules as may appear desirable for the handling of its business.

7b. Action on matters of nomenclature shall be taken by mail ballot, except that final action on written summaries of matters previously submitted for consideration may be taken at the Annual Meeting.

7c. Decisions on matters of nomenclature shall require a majority vote of the Committee, but when the vote is divided five to four the secretary shall submit the case for reconsideration by the Committee. If after reconsideration the vote remains the same, the case shall be submitted to the International Commission on Zoological Nomenclature.

7d. Termination of vote on matters submitted to the Committee by mail shall be upon receipt of five votes that agree, except that the vote shall not be terminated in less than 30 days from time of mailing of ballots unless all votes are in.

#### PUBLICATION.

8. Decisions of the Committee shall be published in summary form, or with such additional explanatory remarks as may be deemed appropriate, in the *Annals of the Entomological Society of America* under the name of Advisory Recommendations.

#### QUORUM.

9. A quorum at any meeting shall consist of a majority of the members of the Committee.

#### AMENDMENT.

10. These By-Laws may be amended by a majority vote of the Committee taken by mail ballot.

Respectfully submitted,

E. G. LINSLEY, *Secretary*.

On motion this report was adopted as read.

Following the call for further business, President Muesebeck declared the meeting adjourned.

#### NEW MEMBERS

BARTHOLOMAI, C. W., 201 Post Office Bldg., Hutchinson, Kansas.

BYARS, L. FREELAND, P. O. Box 1595, Nogales, Arizona.

CAMPBELL, D. K., Box 308, Vernon, British Columbia, Canada.

CAZIER, MONT A., American Museum of Natural History, Central Park West at 79th, New York 24, New York.

CONNIN, RICHARD V., 515 Meyers Street, Toledo 9, Ohio.

DETHIER, VINCENT G., Dept. of Entomology, Ohio State University, Columbus, Ohio.

HERSEBERGER, RUTH V., Dept. of Entomology, Ohio State University, Columbus 10, Ohio.

HILCHEY, JOHN DUNCAN, Fernald Hall, Massachusetts State College, Amherst, Massachusetts.

LAHUE, DELMON W., P. O. Box 54, Swanton, Ohio.

LANHAM, URLESS N., Div. of Entomology and Parasitology, University of California, Berkeley, California.

MALKIN, BORYS, University of Oregon, Dept. of Anthropology, Eugene, Oregon.

MENDER, MANUEL BARRO, Calle 12 Nr. 220, Altos, Apart 3, Vedado, Habana, Cuba.

OWEN, ROBERT P., 401 Washington Avenue, Brooklyn, New York.

PECK, OSWALD, Div. of Entomology, Dept. of Agriculture, Confederation Bldg., Ottawa, Ontario, Canada.

QURAIISHI, M. SAYEED, 15 Hallock Street, Amherst, Massachusetts.

REDLINGER, LEONARD M., 1015 Thurston, Manhattan, Kansas.

SCUDDER, HARVEY T., 284 James Street, Teaneck, New Jersey.

STANNARD, LEWIS J., JR., Dept. of Entomology, University of Illinois, Urbana, Illinois.

STRONG, RUDOLPH G., P. O. Box 1538, State College, Mississippi.

TRAVASSOS, LAURO P., Dept. de Zoologia, Sec. da Agricultura, C. postal 172-A, São Paulo, S. P., Brasil.

WALLACE, HERBERT S., Dept. of Entomology, University of Kansas, Lawrence, Kansas.

WELLHOUSE, WILLIAM T., 1113 W. Tenth Street, Lawrence, Kansas.

WERNER, FLOYD G., 702 Pearl Street, Ottawa, Illinois.

YANCEY, ROBERT M., Dept. of Entomology, Oregon State College, Corvallis, Oregon.



CLARENCE HAMILTON KENNEDY

# ANNALS

OF

## The Entomological Society of America

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Volume XL

JUNE, 1947

No. 2

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### CLARENCE HAMILTON KENNEDY

With the completion of Volume XXXVII of the ANNALS in 1944 Dr. C. H. Kennedy resigned from the managing editorship after almost a quarter of a century of service, beginning with his assistance to Dr. Herbert Osborn in 1920 and culminating with 16 years in full charge of the journal. During that period his devotion to the duties of the office and his artistic approach to the problems of publication raised the ANNALS to an unquestioned place among the leading entomological publications of the world. It is doubtful that the Society, in the increasing tempo of modern life, will ever again find such a willing and able servant for so long a period. Since that period lay chiefly between the two great wars when the cost of publication was comparatively low and progress in entomology was great, the volumes of the ANNALS will stand as a principal monument to his achievement, but he deserves in addition the whole-hearted appreciation of all members of the Society.

Like so many scientists, Dr. Kennedy found his interest in science spontaneously during his boyhood in Indiana. There he became curious about living animals, although he narrowly escaped transplantation into Archaeology when he wrote a thesis on the Indian mounds of the region during his high school years. That danger was averted when he came under the influence of Carl H. Eigenmann at Indiana University where he worked on fishes until the completion of his undergraduate study for the degree Bachelor of Arts in 1902 and graduate study for the degree Master of Arts in 1903.

He was offered an instructorship at Leland Stanford, Jr., University for further work in Ichthyology with David Starr Jordan, but was forced to decline by a break in health. Thus do the accidents of life determine our destiny, for otherwise the world would have lost a great entomologist. Dr. Kennedy did, nevertheless, carry on his work on fishes for a time with the United States Bureau of Fisheries in Washington, but continued poor health deprived him of professional scientific connections for a period of ten years. Some of that time was spent on a ranch in the northwest where his scientific interest found expression in articles on birds and in field work which laid the foundation for his later report on the dragonflies of Oregon and Washington.

In 1914 he returned to Stanford to find that his assistance was no longer wanted in Ichthyology. As a result he began his work in Entomology under Vernon Kellogg. He received the degree M. A. from Stanford in 1915 and transferred to Cornell University for the remainder of his graduate work. There he made the dragonflies his major interest. With the broad vision that has continued to mark his scientific studies he saw the weakness of the classification of the Zygoptera and set out to study the extensive and widely scattered material on which a thorough revision must be based. After examining collections in many institutions and making drawings of the genitalia of all available species he found characters in these structures which led him to revise completely the classification then in use and to reverse the accepted ideas of the trend of evolution in this group. The soundness of his work was later demonstrated by Tillyard's discovery of the most primitive known species, from the Permian deposits of Kansas. This insect was fittingly named *Kennedyia mirabilis*, the type species and genus of the family Kennedyidae. In 1919 he was granted the doctorate in philosophy at Cornell. After a year at Raleigh, North Carolina, he was brought to the Ohio State University to take charge of the courses in entomology which were not economic in emphasis. He has remained in the Department of Zoology and Entomology at that institution ever since, attaining the rank of professor.

Soon after taking up his work in Ohio he began to help Dr. Herbert Osborn with the editing of the ANNALS and was made assistant managing editor, a post which he held until 1929, when he succeeded Dr. Osborn in the editorship. His knowledge of scientific drawing and his keen understanding of the entire field of entomology enabled him to maintain the high standards of content to which the journal owes its eminence. In addition to purely editorial work, he was deeply interested in the publication of notices of outstanding publications in entomology and in more broadly biological subjects, contributing more than 440 ranging from brief notes to full reviews, in addition to selecting items to be reviewed by others. Although the subject of book notices in the Annals has always been controversial, Dr. Kennedy's sound evaluation of the publications that he reviewed was appreciated more widely than many of our members realize. During his editorship he published with the collaboration of Dr. Birely J. Landis, then assistant editor, an article on the preparation of manuscripts for the Annals which resulted in a marked improvement of contributions submitted for publication. This article has also attracted the attention of editors elsewhere as an excellent guide for scientific publication.

During his incumbency at the Ohio State University Dr. Kennedy taught seventeen summers at the Franz Theodore Stone Laboratory on Lake Erie. There he devoted ten summers to collecting Hymenoptera, developing new methods of collecting sawflies and the use of sugar trap lines. With this work his interest finally centered on ants, which he has since continued to study intensively. He has accumulated eight volumes of field notes and 7,000 vials of preserved specimens—an attainment of which one might be proud if it were a major project instead of a secondary interest. With the study of ants, however, he

has constantly increased his collection of Odonata until, in the Andean fauna, it is one of the largest in existence.

His professional accomplishments are attested by a bibliography of more than one hundred titles, chiefly on the Odonata, and by membership in numerous scientific organizations, among them the Society of Naturalists, the Entomological Society of London and the Société Entomologique de France. He was president of the Entomological Society of America in 1935.

Taxonomic studies are fascinating—at least to the taxonomist—and they have greater significance in biology than many scientists realize, but it was inevitable that Dr. Kennedy's inquiring mind should lead him into other problems. Fundamental principles of insect biology were among those problems. His analysis of the family and its place in the evolution of social relationships is one of his most brilliant contributions. The essay, "Some fundamental aspects of insect parasitism", (V<sup>2</sup> Congr. Internat. Ent., Paris) on parasitism as a variable which begins with obligateness to one food, either plant or animal, which is a food continuous in space, on to its high easily recognized forms is receiving more recognition in philosophical biology. Probably the most widely used of his general essays is that on the exoskeleton as limiting insect evolution (*Jour. Morph.*, 1922). Another of equally broad interest is "Evolutionary level in relation to geographic, seasonal and diurnal distribution of insects" (*Ecology*, 1928). This interest led to an invitation to address Cambridge Entomological Club in December, 1946, on the comparison of termite and ant societies, which he interprets as based on child labor versus adult labor respectively. His recent honors have also included an invitation to contribute the general article on Odonata to the new *Encyclopedia Britannica*.

The enumeration of a man's accomplishments on the printed page may be an adequate index to his place in the scientific world, but they are far less satisfactory as a measure of the man. In private life Dr. Kennedy has enjoyed the companionship of a charming and capable wife, nee Lydia June Findley, whom he married in 1927. Mrs. Kennedy is also a member of the faculty of the Ohio State University in the important position of Associate Professor of Home Economics and Director of Dining Halls. They have two children, Bruce Albert Hamilton and Mary Janet. And in addition to his family he has a large number of friends who, even though they may not be concerned with his scientific contributions specifically, will remember him always for his broad comprehension, his keenly analytical insight, his sound logic, and for the bluntness, the frankness, the pungency, and the generous friendliness which characterize the man behind the scientist.

A. W. L.



# THE DEVELOPMENT OF THE GONADS OF THE WOOD-EATING BEETLE, *PASSALUS* *CORNUTUS FABRICIUS*

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The wood-eating beetle, *Passalus cornutus*, is a rather common insect throughout the southern states, where it can be found in old, rotting hardwood logs and stumps. The adult beetles can be collected during the whole year, while in the late spring and the summer months the immature forms are quite plentiful and rather easy to obtain.

*Passalus*, in all stadia, is a comparatively large insect. For example, the adults range in length from 27 to 37 mm., and the eggs, when ready to hatch, average 3.2 to 3.8 mm. This large size of the eggs is of particular interest from an embryological point of view. Furthermore, the developmental stages are of such length as to favor embryological investigations, for the whole cycle from egg to adult is completed in one season—from spring to fall. This fact allows for more convenient and accurate developmental studies than if the course were exceedingly rapid, or extended over several seasons, as is the case in some insects. The duration of the embryonic stadium in the egg is about 16 days; the larval periods occupy from 54 to 60 days; the prepupal stage usually lasts 5 days; and the pupal stadium, 12 days.

Unfortunately, it is extremely difficult to obtain satisfactory serial sections of the eggs, which are almost absolute prerequisites to any embryological study. The yolk is made up of numerous globules of various sizes, and have little or no material to hold them together. The processes of fixation and embedding render these globules so brittle and incohesive that when sections are cut nearly all of the yolk material crumbles and the embryo falls out of the ribbon. Also, difficulties are encountered in sectioning the larval stages, especially the later ones where much wood is present in the gut, for the gut-contents crumble and tear out of the block, and ruin the sections.

Although many investigations have been carried out on the different embryological phases of numerous insects, relatively few workers have traced many structures of the holometabola through all the immature stadia to the imago. In view of the fact that all the various stages of *Passalus* were obtainable in a single season, and since some of the characteristics of this particular insect appeared so conducive to developmental studies, it seemed desirable that one organ, or system of organs, should be traced from its earliest embryonic appearance to the definitive condition in the adult through all intermediate stages. Because the information at hand concerning the development of the sex glands, in insects generally, is somewhat fragmentary and incomplete, the development of the gonads of *Passalus* seemed to be a pertinent topic for investigation.

Inasmuch as an intimate knowledge of the structure of the adult gonads is essential to an understanding of the development of these

organs, the general morphology of the adult male and female gonads has been previously considered (Krause, 1946).

#### MATERIALS AND METHODS

*Collecting:* The horned passalus lives in old, rotting hard-wood logs, where it can be found in tunnels usually close to the bark in the less decayed logs, but a little deeper in softer and dryer ones. Both parents and offspring inhabit the same set of tunnels, and during the breeding season the adult male and female invariably remain close together. Eggs are usually laid in a single group in a small side tunnel. As the female lays only a few eggs a day, eggs of various ages can be found in any particular group. When the eggs hatch into larvae, the young beetles wander around in the tunnels, and eat the frass their parents have prepared for them. During the prepupal stage they become quiescent, and the parents enclose them in frass cases where pupation subsequently occurs.

After the adult beetles were collected in the woods, they were brought into the laboratory and placed in individual finger-bowls with a little frass and damp wood. Each day the bowls were examined so that when eggs were found, they were known to be less than one day old. In some cases, known egg-layers were examined hourly in order to obtain eggs in very early stages of development. The beetles kept in the laboratory did not lay many eggs—never more than six, and usually less. After three or four days they ceased laying, and were then returned to the woods.

All eggs collected were incubated as close to 28° C. as possible, but considerable variation in temperature did occur. Moisture content was maintained by dampening the frass with tap water. Eggs of unknown ages collected in the woods were allowed to hatch in the laboratory, and in this way first instar larvae of known age were obtained.

The larvae collected in the woods were all placed in large bowls—each bowl containing only larvae of the same stage—and when they molted they were separated into individual bowls. As they were examined twice daily, their ages were known to within twelve hours. The instars were very easy to distinguish by the width of the head, in accordance with Dyar's Law. First instar larvae measure, on the average, between 8.3 mms. and 19.6 mms. with a head width of 2.0 mms. to 2.6 mms.; second instar larvae from 18.5 mms. to 31.8 mms. in length, and 3.0 mms. to 3.7 mms. in head-width; third instar larvae from 26.3 mms. to 43.0 mms. in length and 4.5 mms. in length and 4.5 mms. to 5.7 mms. in head-width. The whiteness of the integument, especially of the head and mouthparts, readily identified a newly-molted larva.

Prepupae and pupae were obtained in the same manner as the larvae. The prepupae were exceedingly difficult to distinguish, because the transition from the third instar to the prepupal stage is rather gradual. But, once the prepupal stage was reached, they could easily be identified by the whiteness and softness of the integument. The pupae, of course, were easily recognized. Young pupae were creamy white in color, whereas older ones took on a pinkish tinge.

A difficulty arose in obtaining an adequate supply of prepupae and pupae, because of the ravages of a dipterous parasite, *Zelia.vertebrata*,

which produces a high mortality in these stages. No infected *Passalus* reaches maturity, for when the parasite has completed its own larval growth the maggot emerges through the body wall of the host, causing the death of the latter. Because *Passalus* may be in the late larval, prepupal, or pupal stage when the maggot emerges, the supply of these stages is greatly diminished.

*Fixation and Preservation.* Most eggs and embryos were fixed in alcoholic Bouin's fluid for two days. After the first day of fixation a slight puncture was made through the chorion with a fine needle to facilitate penetration. In some cases the chorion was removed, and in others it was left attached. Removal of the chorion offers certain technical advantages, but it is a tedious process and often results in damage to the delicate embryo. The eggs were washed and stored in 85% alcohol. Although in several instances eggs were fixed in Carnoy-Lebrun's solution, the former method of fixation was used almost exclusively, as the technique for sectioning eggs had not been perfected and many specimens were lost. It seemed preferable to use one good standard fixative rather than to experiment with various preservatives, because of the limited supply of certain stages, notably eggs and prepupae of known ages. Larval, prepupal and pupal stages were all immersed in alcoholic Bouin's fixative. After a short time the portion anterior to the second thoracic segment was cut off, and in the larger ones the integument was also nicked to increase penetration of the fluid. They were then washed, after two days of fixation, and stored in 85% alcohol.

*Embedding and Sectioning.* After fixation the specimens were dehydrated through 95% and absolute alcohol. They were infiltrated and imbedded in celloidin, cleared in toluene, re-infiltrated and imbedded in paraffin, then sectioned at 4 to 12 microns. Prepupae and pupae were not doubly imbedded, but could be cut satisfactorily when imbedded in paraffin alone.

*Staining.* The slides were stained in either Delafield's or Harris' dilute hematoxylin, and destained with picric acid solution or acidulated water until differentiated. Counterstaining was accomplished by using eosinol (eosin in carbol-xylol), or Orange G in clove oil or 95% alcohol.

The technical methods employed involve several important points which warrant special consideration and emphasis. The use of double embedding routine in celloidin and paraffin is one way to avoid crumbling when early egg and late larval stages are sectioned.

The process of infiltrating with celloidin is, in itself, a long and tedious process, but the time required can be greatly shortened by using the so-called "hot-celloidin" method where the celloidin infiltrates under pressure. But instead of the corks of the vials being wired to prevent them from blowing out, several small vials were placed in a screw-top jar. When the lid of the latter was screwed on, it pressed firmly against the corks of the specimen vials. With this arrangement the jar and vials could be placed in the warm paraffin oven with no danger of the corks flying out. Of course, when the reagents were changed it was necessary to allow the jar and vials to cool slowly, so that the pressure inside the vials was reduced to normal.

Another important fact is notable in the staining technique. In order to prevent the celloidin-paraffin sections from falling off the slide during hydration and the staining procedures, it is almost a necessity that the slides be dipped in 1% celloidin after deceration, so that a thin protective celloidin film is acquired. Likewise, this precaution must be taken in staining pupal and prepupal stages, even though they are paraffin sections. The celloidin film prevents the histolyzed material, so abundant at these stages, from tending to flake off during staining and washing. However, when this celloidin film is applied, the use of such stains as crystal violet, Mallory's connective tissue stain, and the anilin dyes is naturally precluded, because the celloidin itself takes up these stains so readily.

#### ORIGIN OF THE GERM GLANDS IN THE COLEOPTERA

For a group as large as the Coleoptera there has been comparatively little work done on the development of the gonads. Because the history of these structures does seem to vary somewhat in the different genera studied, it is essential to examine the literature on the beetles very closely. Where principles are involved it is also necessary to consider briefly what has been found in other orders, and to use this information as a background for observations and interpretations in a study of the Coleoptera.

Although the time of origin of the germ glands differs considerably in the various orders and families of insects, the primitive germ cells typically arise quite early in development as a group of cells at the posterior pole of the egg. With the formation of the amnion they migrate through the blastoderm, and lie between the primary epithelium and the yolk. Later, resuming their migration forward, they pass anteriorly while the proctodaeum and coelomic sacs are formed and are situated between the yolk and endoderm. After dividing into two masses at about the ninth and tenth abdominal segments, one mass migrates to the right, the other, to the left into the mesoderm. With the appearance of the coelomic cavities, the germ cells move still farther forward, penetrate the genital ridge, multiply, and form a group of cells surrounded by the tissue of the genital ridge. This aggregation of cells is considered to be the gonad anlage.

In some insects these primitive germ cells can easily be distinguished from somatic tissue-forming cells. In others, however, the germ cells cannot be recognized as such until comparatively late in development. It is possible, moreover, that the late differentiating germ cells do have a previous history similar to that of the early segregating primitive germ cells, but because of their resemblance to somatic cells, this cannot be demonstrated.

Suckow (1828) believed the gonads in insects arose by budding from the gut at an early embryonic stage as an outgrowth from the hind intestine.

Through the work of Robin (1862) on *Chironomus*, Weismann (1863) on *Musca*, Metschnikow (1865) on *Cecidomyia*, and Leuckart (1865) on *Miasitor*, it was shown that a group of "pole cells" arose at the posterior end of the egg with the formation of the blastoderm. Balbiani (1866, 1885), studying aphids and *Chironomus*, followed the later history of

these pole cells. He showed they were derivatives of the cleavage nuclei, and subsequently developed into the sex gland anlage, thus having the significance of primitive germ cells.

Ritter (1890) described in *Chironomus*, and Noack (1901) in *Calliphora*, a dark granulated layer at the posterior end of the egg. The latter author declared this structure was intimately concerned with the development of the pole cells.

Hegner (1909) described this disc-shaped mass as consisting of darkly staining granules. These granules were of large size, and stained readily with hematoxylin, thionin, and gentian violet, giving as deep a color as that of the chromatin. When stained with Orange G they were more intensely colored than the surrounding cytoplasm, and nearly as dark as the yolk globules.

Working on chrysomelid beetles, Hegner concluded that the cleavage nuclei were all potentially alike, and that the cytoplasm controlled the differentiation into nuclei of blastoderm cells, primordial germ cells, and vitellogophages. He could not definitely determine the genesis of the pole-disc, but it appeared just before the oocyte reached full size in the ovariole.

In a series of experiments which involved the destruction of the pole-disc area and subsequent development of the egg, Hegner (1908 to 1911) concluded that the pole disc granules are engulfed by the pole cells and actually do "determine" the germ cells.

More recently other authors have found an early segregation of germ cells. Huettner (1923), however, claimed that in *Drosophila* the pole-disc was of no significance in germ cell determination. Gambrell (1933) in *Simulium*, Auten (1934) in *Phormia*, Lassmann (1936) in *Malophagus*, DuBois (1932) in *Sciara*, Henschen (1928) in *Habrobracon*, and Gatenby (1918) in *Trichogramma*, all found that the germ cells segregated from the somatic cells at an early stage of development.

In addition to the work of Hegner on *Calligrapha* and *Leptinotarsa*, several other investigations have been carried out on Coleoptera concerning the early segregation of germ cells. Butt (1936) working on *Brachyrhinus*, Paterson (1936) on *Corynodes*, and Inkmann (1933), Wray (1937), and Tiegs and Murray (1938) on *Calandra*, found a typical early differentiation of germ cells. However, in the last mentioned genus (*Calandra*) the workers found no indication of the pole-disc or germ cell determining area at the posterior part of the egg. Brauer (1925) found that pole cells were formed at the posterior end of the egg in *Bruchus*, but the later history of these was not followed.

Although Hirschler (1909) is considered by others to have stated that the germ cells in *Donacia* arise later in development but before segmentation, as I understand him, he claims that by following the wandering of the germ cells up to the seventh abdominal segment, he could possibly show an early segregation of germ cells.

Will (1888) working on aphids, Woodworth (1889) on *Euvanesa* (Lepidoptera), Heymons (1890-1891) on *Blatta*, (1897) on *Lepisma*, Shinji (1919) on the coccid *Lecaniodiaspus*, all found the origin of the germ cells from the mesoderm at the gastrulation stage, but before segmentation had occurred.

Sehl (1931) in *Ephestia*, Nelsen (1934) in *Melanoplus differentialis*,

Mellanby (1936) in *Rhodnius*, Schwangert (1905) in *Endromis* (Lepidoptera), and Lautenschlager (1932) in *Solenobia* (Psychidae) found a similar differentiation of germ cells at the posterior end of the germ band.

Hodson (1934) found, among the Coleoptera, that *Tribolium* proliferated a mass of cells at the posterior extremity of the germ-band, and this mass ultimately produced the various constituents of the caudal plate. At first all the cells were alike in possessing large nuclei with scattered chromatin granules. Later, as the mass of cells moved dorsally, differences could be noted in the structure of the nuclei. Those which composed the ectoderm became slightly oval, and were restricted to the ventral margin of the mass; those that composed the mesoderm became smaller, and were characterized further by their densely packed chromatin granules, while others retained their original appearance, and were recognized eventually as the definitive germ cells. During this process of differentiation, the germ cells became crowded into the inner central portion of the developing caudal plate.

Investigators have found that in many insects the germ cells arise from the wall of the coelomic sacs after segmentation has taken place. Ayers (1883) in *Oecanthus*, Clappole (1898) in the thysanuran *Anurida maritima*, Wheeler (1889, 1893) in *Xiphidium*, Graber (1891) in *Chalici-doma*, and Seidel (1924) in the bug *Pyrrhocoris*—all observed that the gonads arose with the first occurrence of the mesodermal sacs.

Wheeler (1889, 1893) believed that in *Leptinotarsa* the germ glands originated as two elongate thickenings of splanchnic mesoderm, one on each side, projecting into the body cavity. Later they rounded up and were attached by only a thin strand of splanchnic mesoderm. There were several cells of an embryo which might have been comparable to the pole cells but the genesis and later history of these cells was not followed. Hegner (1908) showed that the pole cells in *Leptinotarsa* were actually the early segregated germ cells.

Heider (1889), in studying *Hydrophilus*, recorded that the germ glands originated from the inner wall of the primitive abdominal segments, one on each side of the body, arising as solid out-growths from that part of the wall of the somites which lay between the place of origin of the fat-body-band and the splanchnic layer of mesoderm. Graber (1891) also studying *Hydrophilus*, found the same type of origin of germ cells as Heider did.

Saling (1907), in studying *Tenebrio*, was unable to find germ cells at the blastoderm stage (in contrast to the Chrysomelidae). At the time of amnion up-folding, an invagination of the ectodermal part of a group of cells appeared which was probably the germ cell mass. He was not certain of it, for in this early stage of development it was apparently exceedingly difficult to distinguish them. The main criteria for the germ cells in later stages, such as the characteristic nuclear structure, and the arrangement of chromatin in the nucleus, were not clear in the early stages.

By the forward-pressing of the segmentally arranged mesoderm masses, the still unpaired genital anlage was pushed forward, and it arrived, with the formation of the primitive cavities, at the boundary of the sixth and seventh abdominal segments. By a division in a lateral direction, it became paired, and connected with the coelomic sacs of

the seventh abdominal segment formed in between. For the first time the genital anlage could definitely be recognized as such.

#### DEVELOPMENT OF THE GONADS IN THE COLEOPTERA

While the origin of the germ cells varies greatly in the different orders and genera of insects, the actual formation of the sex glands is much more similar, fundamentally, throughout the whole group. For this reason, only the beetles will be considered in the survey of gonad formation.

In such a type as *Calandra granaria*, in which the germ cells are set aside at a very early stage in blastoderm formation, Inkmann (1933) found that these cells multiplied at the posterior pole of the egg, forming a somewhat bulged-out mass. At this stage the mass was clearly visible because of its increase in size. While the germ-band lengthened, the genital cells remained as a single round mass, but became paired when they were enclosed and rolled under the proctodaeum as it tucked under the tail portion of the embryo.

With the continued overgrowth and elongation of the germ-band, the germ cells were carried toward the anterior pole of the egg where they formed a conspicuous clump of rather pale cells just below the surface.—Tiegs and Murray (1938). From this position at the hinder end of the germ-band they moved forward again, into the developing abdomen, as the proctodaeum elongated. By the second day of development, the mass had moved almost to the eighth segment. At about this time the germ cells came into close contact with the adjacent coelomic sacs, and the masses divided into left and right halves. The lower parts of the splanchnic walls of the more posterior abdominal coelomic sacs were composed of quite small, scattered cells lacking any regular epithelial alignment. It was from these that the enveloping sheath of the gonad arose. As the germ cells came into contact with the coelomic sacs, the latter became indented by them, and the coelomic cavities were thereby obliterated.

The investing sheath acquired by the germ cells was composed, at first, only of scattered cells, but later it became consolidated into a continuous membrane. This penetration of sex cells into the coelomic sacs of *Calandra* occurred in the middle of the third day, just before the beginning of the shortening of the embryo. At this time the cavities of the sacs had become confluent, and the differentiation of the walls was beginning. From the ninth, eighth, and seventh sacs, where penetration occurred, they migrated forward as a compact cord of cells three to four segments in length until they reached the third abdominal segment—at the end of the third day. When the gonads reached that level the fat-body had already become well defined. The gonads were spherical masses and lay amid the fat-cells dorsally, being carried up by the spread of the body walls. During the fourth embryonic day the gonads moved back to about the fourth abdominal segment.

Wray (1937) found essentially the same history of germ cells for *Calandra callosa*, but records that the gonads extended as elongate bodies up to the first abdominal segment and were situated in a dorso-lateral position. While the median mesodermal well of the coelomic sacs was differentiating, a portion surrounded the genital rudiment,

forming a fine filament which connected it with the dorsally situated pericardial septum.

Tiegs and Murray (1938) claimed there was no connection with the developing heart, as is typical in orthopteran embryos.

*Tribolium* is an example of the type of beetle in which the germ cells originate from the mesoderm before segmentation. Hodson (1934) records that after segmentation occurred and the proctodaeum had become invaginated, the germ cells were found in a large aggregation in the region of the sixth and seventh abdominal segments. Soon the group became divided into three masses; two remained near the sixth and seventh segments, while the other migrated to the fifth. During the time the germ cells were moving from the original groups, the coelomic sacs began to form, and the neural groove and ganglia could be seen.

After about thirty-two hours of development the masses of germ cells had a different appearance. Each had divided into two compact clusters and were gradually sinking into the coelomic cavities of segments 5, 6, and 7 on both sides of the embryo. Later, the germ cell groups were completely surrounded by the walls of the coelomic sacs, and began to acquire a delicate mesodermal epithelium.

The germ glands soon became much shorter and extended from the posterior edge of the fifth abdominal segment into the anterior part of the seventh. The glands were carried toward the dorsal part of the egg with the upward migration of the heart rudiment. Until differentiation of the sexes, there were no changes in structure of the gonads, although their position was altered in such a manner that they came to lie near the mid-dorsal region of the embryo, on either side of the heart.

In *Tenebrio*, which has a rather late differentiation of germ cells, Saling (1907) summarized the embryonic development of the gonads. The young genital anlage broke through the median wall of the seventh abdominal segment and connected with the coelom. Through this break in the coelomic region the genital anlage acquired its mesodermal sheath, with the epithelium having arisen out of the part of the coelomic wall which lies directly near the germ gland. The fat-tissue pushed itself around the anlage from below. Further, the terminal filament plate formed out of the medio-dorsal wall of the reduced coelomic sac.

The main role in subsequent development was played by the terminal filament plate, for it accomplished the fastening of the germ gland anlage to the visceral layer. With the growth of the germ-band over the yolk, the terminal filament raised up the anlage. Thereby, the part of the terminal filament plate next to the visceral layer drew itself to the hanging thread, while the section adjacent to the gonad anlage transformed into the terminal filament. The attachment of the genital anlage persisted through all stages of development, and toward the end of the embryonic period the connecting band fused with the pericardial septum.

In *Tenebrio*, Saling (1907) recorded that sex differentiation began shortly before the close of the embryonic period. The testis formed six diverticula, whereas the ovary possessed twelve; each of these agreed with the number present in the testis and ovary of the imago.

Tracing the larval history of the gonads in *Tenebrio*, Saling reported



that the ovary and testis anlagen, at the beginning of their post-embryonic development, were very similar and could be distinguished with certainty only by the number of diverticula formed. During the earliest post-embryonic period the gonads on each side of the fat-body became surrounded by a very delicate peritoneum. The sickle-shaped cells widened through the epithelial division on the wall of the young sex gland diverticulum in which the germ cells occurred. In this manner, these elongate cells gave rise to the ovariole tubes and testicular follicles. The sickle-shaped cells of the ovary anlage pressed together at the terminal pole of the ovarian tube, and formed here a rather extensive terminal apparatus, which later grew into a typical terminal filament. The elongate cells of the testis anlage congregated in the germ compartment of the testicular follicle, encompassed the spermatogonia, and played the role of nurse cells. Homologous with the terminal filament of the ovary, there arose in the testis a smaller terminal apparatus which degenerated during the pupal stage.

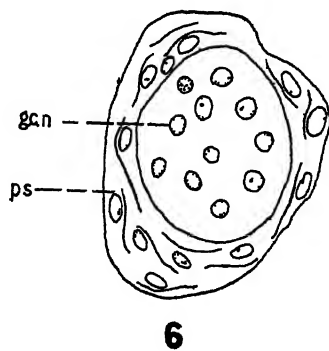
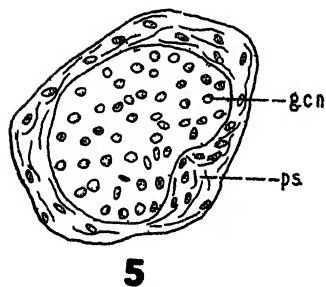
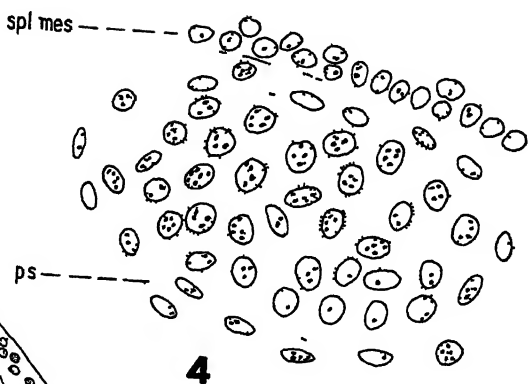
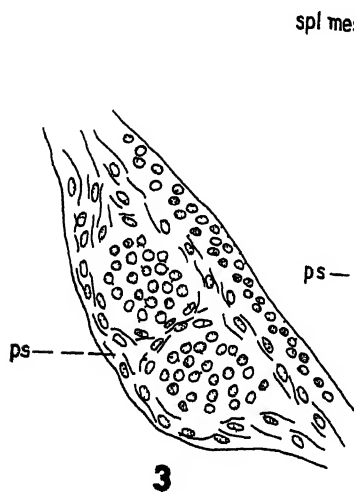
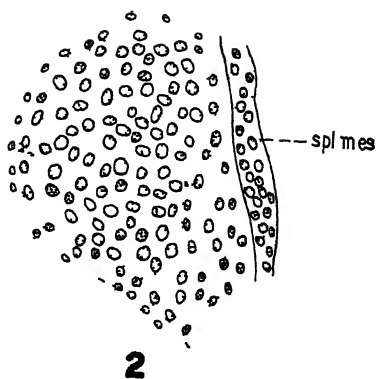
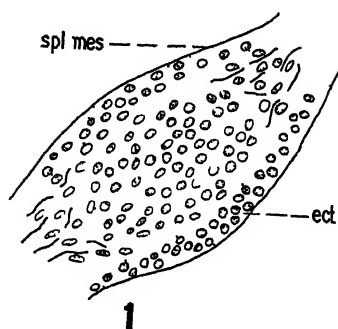
Wieman (1910) described the female gonad development in *Leptinotarsa*, and stated that at the close of the larval period very simple conditions prevailed which permitted the distinction between germ cells and epithelial cells, while the nurse cells were not yet differentiated. The germ cells had not changed appreciably since their appearance in early embryonic stages.

In the region of the terminal chamber two kinds of cell could be made out: the large germ cells with deeply staining cytoplasm and nuclei showing an irregular chromatin reticulum, and the small pale epithelial cells continuing outward into the terminal thread. The ovariole stalk was composed of tall columnar cells, while the peritoneal sheath was in the process of formation and was represented by the large epithelial cells which were flattened against the sides of the tube. Beneath this outer sheath lay the tunica propria bounding the terminal thread and chamber. The ovarioles were united by their terminal threads coming together on either side into a single bundle which was inserted into the dorsal wall of the body cavity.

Wieman traced the development of the larval male gonad saying that each lobe of the testis was of cylindrical form, resembling a single ovariole of the ovary. As in the latter, both the epithelial and germ cells could readily be identified. In the following stages the increase in size took place primarily at right angles to the axis, but not equally.

#### EXPLANATION OF PLATE I

FIG 1 Transverse section through the abdominal region (segments 6 and 7) of a 9-day-old embryo showing the first indication of the gonad. *ect*—ectoderm, *spl mes*—splanchnic mesoderm. X 266. FIG 2 Longitudinal section through the gonad anlage of a 10-day old embryo. *spl mes*—splanchnic mesoderm. X 266. FIG 3 Transverse section through the gonad of an 11-day old embryo showing the division into two parts at the distal end. *p s*—peritoneal sheath. X 266. FIG 4 Transverse section through the gonad of a 9-10 day-old embryo. *p s*—beginning of peritoneal sheath, *spl mes*—splanchnic mesoderm. X 825. FIG 5 Transverse section through the base of the gonad of a late embryo. *g c n*—nucleus of germ cell, *p s*—peritoneal sheath. X 371. FIG 6 Transverse section through one arm of the gonad of a late embryo. *g c n*—nucleus of germ cell, *p s*—peritoneal sheath. X 825.



in all directions, for it was inhibited at regular intervals which marked the spaces between the radiating follicles. The original apex was represented in the adult organ by a cap-like lobe which lay just opposite the aperture of the sperm duct. The epithelial investment, at first rather loose, in late pupal stages enlarged between the follicles and produced the appearance that characterized the adult, in which the follicles were separated from each other by a thick layer of epithelial cells. Areas of degeneration could be seen in all stages of the testis beginning in the larva and extending through the adult. The process commenced with the accumulation of epithelial cells in the region representing the lumen of the general cavity of the testis continuous with that of the sperm duct of the adult. The cells involved fragmented and produced irregular masses which stained deeply with basis dyes. This process of degeneration was regarded as a method of providing nutrition material either for the sperm or germ cells, and these degenerating cells could thus be looked upon as nurse cells.

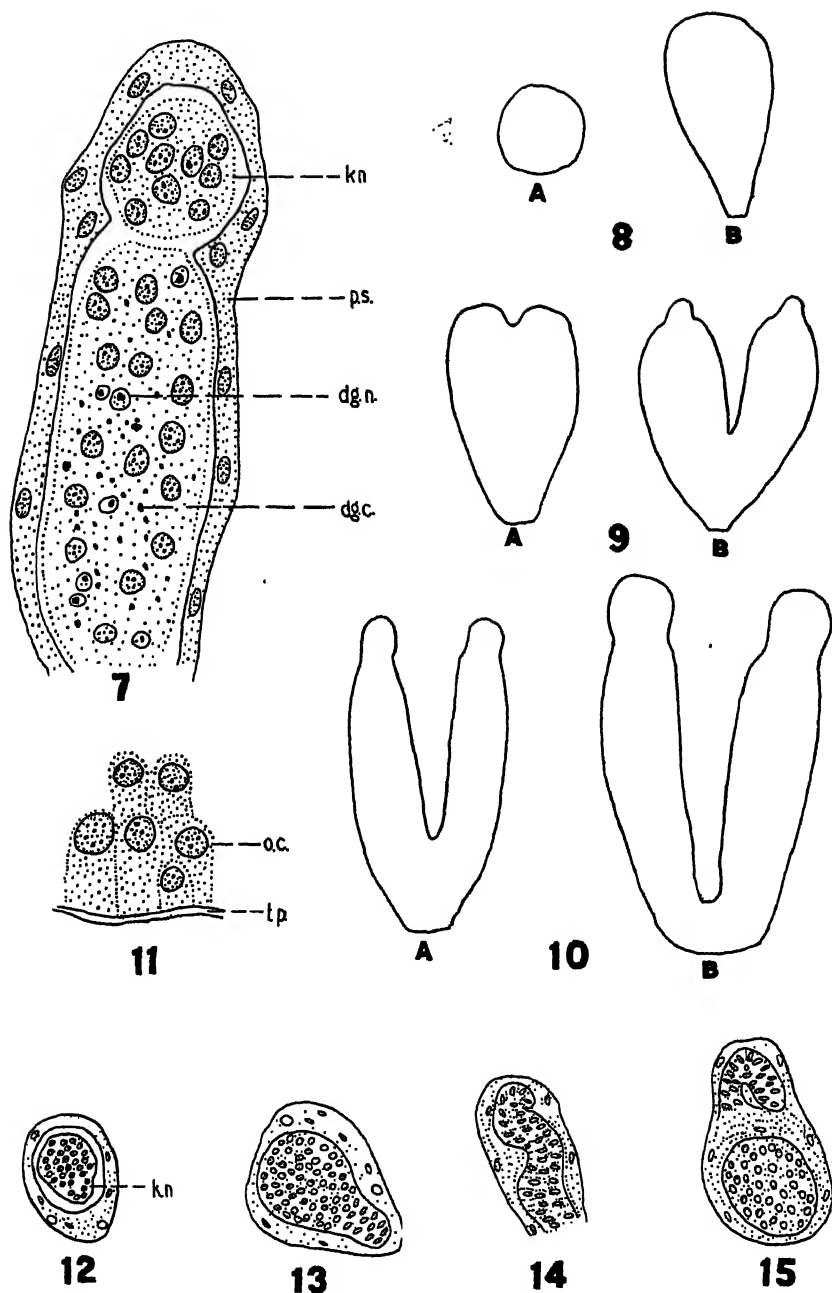
Hodson (1934) found the first indication of differentiation of the male and female sex organs in *Tribolium* just before the eggs were to hatch. The ovoid germ gland presented a rough appearance which was brought about by a rearrangement of the mesodermal cells on the inner side of the gland. Because the sex of the embryo could not be definitely determined at this stage, it was necessary to study the newly hatched larvae in order to distinguish male from female. As the rudimentary tubules increased in length, their nuclei became more prominent and differed from those of the germ cells. They were sickle-shaped and seemed to contain a solid mass of chromatin. In the case of the male there were six tubules which ultimately composed the testicular follicles, whereas the female gonad had eight protuberances which occurred in double rows of four on the inner lateral surface of the gland.

Murray and Tiegs (1935), working on the development of the gonads in *Calandra*, recognized the anlage of the ovary in the smallest larva. There were a pair of rounded rudimentary ovaries embedded in the fat-body connected by the very delicate stalks to the imaginal discs at the base of the ninth segment. During larval life the ovaries enlarged and, even in the young larva, became constricted into two pyriform bodies. In the early prepupa the development proceeded much more rapidly. The stalk lengthened and bent, but it was not until shortly before pupation that a lumen developed in it. Histological differ-

#### EXPLANATION OF PLATE II

FIG. 7. Longitudinal section through the arm of the gonad of a late embryo. *dg. c.*—degenerated cell; *dg. n.*—degenerating nucleus; *kn*—knob of cells at tip; *p. s.*—peritoneal sheath.  $\times 825$ . FIG. 8. Diagram showing approximate shape of gonad anlage at various stages. *A*—first appearance (9 days); *B*—10 days. FIG. 9. Diagram showing approximate shape of gonad at: *A*—about 11 days; *B*—late embryonic stage. FIG. 10. Diagram showing approximate shape of gonad at: *A*—Early first instar larva; *B*—second instar larva. FIG. 11. Transverse section through part of the ovariole of a prepupa showing formation of the tunica propria. *o. c.*—cell of ovariole; *t. p.*—tunica propria.  $\times 825$ . FIGS. 12–15. Sections showing elongation of distal tip of ovariole in prepupal stage. *kn*—knob.  $\times 88$ .

NOTE: Figures 8, 9, and 10 are not drawn to scale.



entiation in the ovary occurred in the early larva. At the attachment of the ovary to its stalk was a group of small cells which were destined to form the vitellarium in the adult ovary. Distally, the oogonia were invested by a thin sheath that was continuous with the anlage of the vitellarium.

The male gonad in the larval stage consisted of a single pair of testes dorsal and behind the midgut, embedded in the fat-body, and similar to the ovaries in structure. During larval life the testes enlarged, and each divided into two parts. Later there was a migration of the testes which in the late pupa moved downwards and came to lie ventrally in the abdomen. Simultaneously, they enlarged and a partial fusion of the testes on either side took place. According to the authors, mature spermatozoa could be seen in the newly formed pupa.

Although there does seem to be a common plan upon which the adult gonads of the beetles are constructed, the origin and actual formation of these glands is quite varied. With a brief review of how the sex glands are formed in Coleoptera and other orders, it is now possible to see how the beetle, *Passalus*, fits into the picture as far as the development of the gonads is concerned.

#### OBSERVATIONS

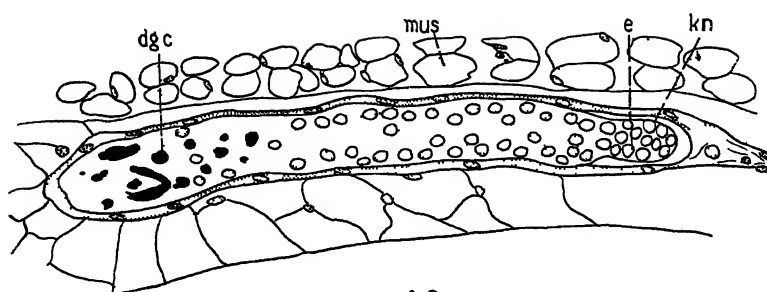
Although many young eggs were examined—some of them less than 5 hours old—there was no indication of a dark granular pole disc, or oosome, at the posterior end of the egg, nor of clearly defined pole cells being set aside at this region. The cleavage nuclei, the cells of the blastoderm, and the cells at the caudal region of the germ band exhibited no morphological or staining qualities which might identify some of them as the primordial germ cells.

The earliest indication of the embryonic gonads, that is, the period when the germ gland anlage can be definitely recognized as such, occurs in an approximately 9-day embryo. At this period of development the lateral edges of the germ band have grown nearly one-third the way to the dorsal side, where eventually the right and left edges will meet. The fat body can be seen beginning to form between the splanchnic and somatic layers of the mesoderm. Near the most dorsal edge of the up-growing germ-band, in the region of the sixth and seventh abdominal segments, a slightly bulging, dense mass of cells can be seen on each side of the embryo adjacent to the splanchnic mesoderm (fig. 1).

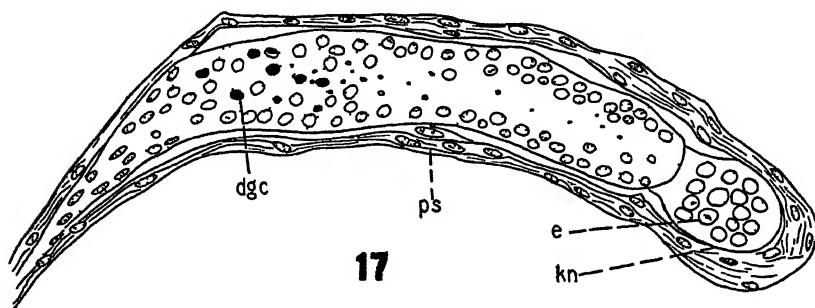
In this thickened mass of dense cells there does not seem to be any regular or definite arrangement, and there is nothing distinctive about the individual cells to enable one to differentiate them from other

#### EXPLANATION OF PLATE III

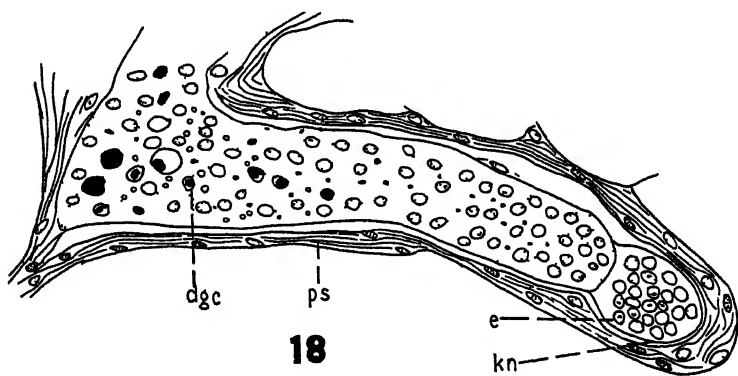
FIG. 16. Longitudinal section through the gonad of a 6-day-old first instar larva. *dg. c.*—degenerated cell; *e.*—nucleus of cell in knob; *kn*—knob at distal tip; *mus*—muscle.  $\times 400$ . FIG. 17. Longitudinal section through the gonad of a second instar larva. *dg. c.*—degenerated cell; *e.*—nucleus of cell in knob; *kn*—knob at distal tip; *p. s.*—peritoneal sheath.  $\times 400$ . FIG. 18. Longitudinal section through the gonad of a second instar larva (next section to that shown in fig. 17). *dg. c.*—degenerated cell; *e.*—nucleus of cell in knob; *kn*—knob at distal tip; *p. s.*—peritoneal sheath.  $\times 400$ .



16



17



18

similar cells of the embryo. Neither the nuclei nor the cytoplasm exhibit any obvious morphological or staining characteristics that might identify them as primordial germ cells. But by a tracing backward of the development of the gonad, it is quite certain that this dense mass of cells is actually the earliest indication of the gonad anlage. Presently, however, some cells with slightly smaller, ovoidal nuclei tend to line up with their long axes following the somewhat oval outline of the mass of cells.

In a slightly older embryo of about 10 days, the gonad anlage appears even more condensed and ovoid in shape (fig. 4). There also seems to be a more definite alignment of the slightly smaller ovoidal nuclei about the dense mass, indicating that a compact peritoneal sheath (*p. s.*) is beginning to be formed. At about this stage of development a longitudinal section of the gonad anlage reveals that it is a tear-drop, or Comet-shaped structure with the blunt end forward and the tail, or narrower end, tapering posteriorly (figs. 2 and 8).

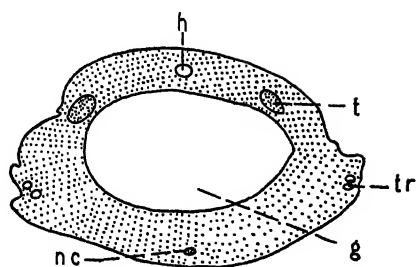
At about the eleventh day of development the germ band has grown approximately one-half the way around to the dorsal side. At this stage the gonad rudiment at the anterior end becomes constricted in the middle and divided into two parts (fig. 3), giving the gland the beginning of a Y-shaped appearance (fig. 9, *A*). The base and each arm of the Y-shaped gonad become cylindrical (figs. 5 and 6) and are surrounded by the sheath of cells with slightly elongate ovoidal nuclei (*p. s.*).

At the time the left and right edges of the germ-band have joined at the middorsal line of the embryo the gonad has further divided into the two cylindrical arms of the Y, and the base has become relatively shorter (fig. 9, *B*). Meanwhile, at the most anterior and distal tip of each arm a small group of cells has formed a round ball-like knob (fig. 7, *kn*). Also at this time many round, black-staining, extra-cellular masses are evident in the gonad (fig. 7). At first the chromatin portion of the nucleus seems to clump and become very black (*dg. n.*). Other small dark masses (*dg. c.*) appear between the different cells. These extra-cellular masses have probably been liberated from the degenerating nuclei.

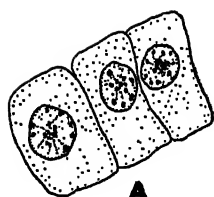
A longitudinal section through a first instar larva reveals that the division of the gonad into its component parts is almost complete (figs. 16 and 10, *A*). The length of one arm plus the short common base is about 0.2 mm., and the width of the tapering cylindrical arm is about 0.025 to 0.04 mm. near the middle. The whole structure still lies

#### EXPLANATION OF PLATE IV

FIG. 19. Diagram showing the relative position of the gonads in the prepupal stage. *g*—gut; *h*—heart; *n. c.*—nerve cord; *t*—testis; *tr*—trachea. FIG. 20. Longitudinal section through the testis of a prepupal stage. *a*—cell near periphery; *b*—cell near center; *c*—transverse, elongate cell; *dg. c.*—degenerated cell; *kn*—knob at tip; *sp. cy.*—sperm cyst. × 88. 20A—Group of columnar cells near periphery. × 825. 20B and C—Cells near center. × 825. 20D—Group of cells with degenerating nuclei. × 825. FIG. 21. Diagram showing relative position of the testes in the pupal stage. *ef. dt.*—efferent duct; *h*—heart; *h. g.*—hind gut; *t*—testis; *tr.*—trachea.



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A



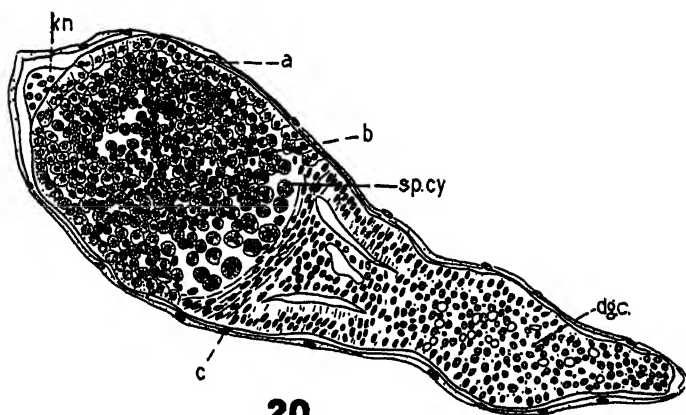
B



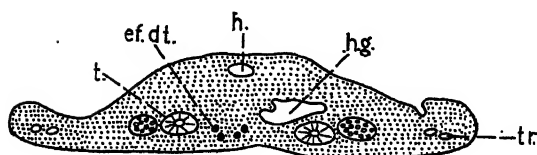
C



D



20



21



embedded in the fat-body in the vicinity of the sixth to seventh abdominal segments, with the distal free ends pointing dorsally and anteriorly, and the proximal base portion extending ventrally and posteriorly. In the region of the base and near the central portion of the gonad the black globules have coalesced and run together to form irregularly shaped masses (fig. 16, *dg. c.*). At the distal tip the group of cells (*e*) forming the knob (*kn*) is still in prominence.

In a second instar larva a longitudinal section through the developing sex gland shows that the same histological conditions prevail (figs. 17 and 18) as in the first instar. But a slight increase in width is now noticeable. The base of the gonad tapers off gradually in a ventro-posterior direction. At the crotch of the Y-shaped structure and at the central region of the cylindrical arms there are still black-staining masses rather extensively present (*dg. c.*) and a few vacuoles appear in this region.

In a third instar larva conditions are still relatively unchanged, although the width now measures 0.045 to 0.055 mm. Small tracheae and tracheoles can be distinctly seen entering the outer peritoneal sheath of the gonad.

**Prepupal Stage:** During the prepupal stadium the developing gonads lie close to the dorsal side, a trifle lateral to the heart (fig. 19). In the male individual there is a great increase in the size of the anlagen, each of which now measures approximately 1.0 mm. in length, and about 0.35 mm. at the widest point.

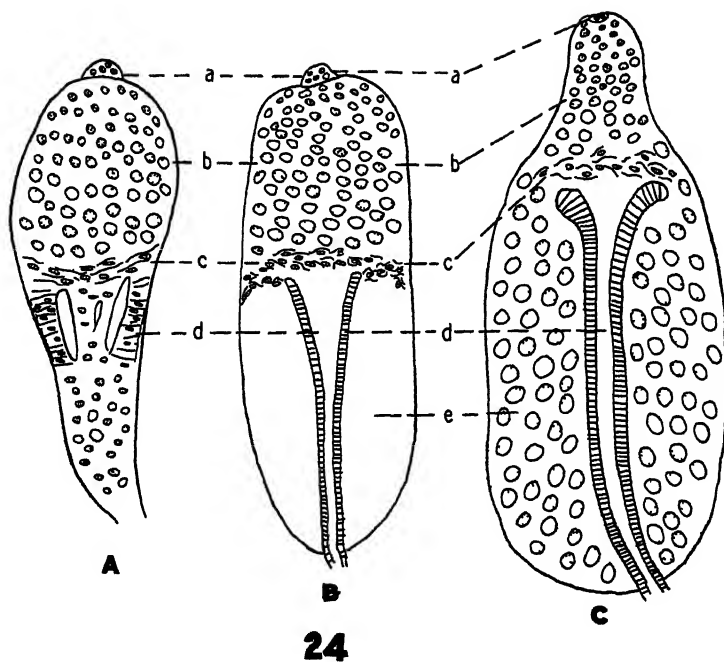
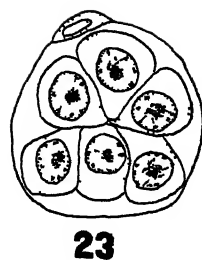
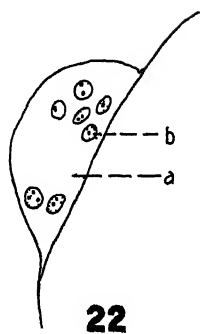
With the formation of sperm cysts (figs. 20, *sp. cy.* and 23) near the middle of the gland, it is definitely indicated that the developing gonad is a testis. Toward the peripheral portion of the distal region the cells are arranged in a type of tall columnar epithelium (fig. 20, *A* and *a*). Just inside these, the cells are less closely packed together and assume a more nearly spherical or polyhedral shape (*B*). The former columnar type cells at the edge of the gland can be seen dividing and giving rise to additional cells in the central portion, which take on the characteristic polyhedral shape.

The nuclei of the cells of the testis at the early prepupal stadium exhibit no definite tendencies toward a meiotic division, and also because of their location, it is almost certain that these testis cells are in the spermatogonial stage. Near the lower part of the distal region these spermatogonia become enveloped by sperm cyst capsules (fig. 23).

At the distal tip of the testis the little knob of cells now appears as a small hillock projecting from the end of the enlarging gland (figs. 20 and 22). Along with the group of cells there is a somewhat lighter staining mass (*a*) surrounded by the former. The whole mass is completely cut off by the very thin non-cellular sheath (*b*).

#### EXPLANATION OF PLATE V

FIG. 22. Section through the tip of a prepupal testis showing the mass of cells. *a*—lightly staining mass of protoplasm; *b*—non-cellular sheath.  $\times 371$ . FIG. 23. Cyst of spermatogonia from prepupal testis.  $\times 825$ . FIG. 24. Diagrams showing formation of testicular septa and sperm duct. *A*—Prepupa; *B*—Early pupa; *C*—Adult (not drawn to scale). *a*—distal mass of cells; *b*—protuberance; *c*—epithelial arch; *d*—sperm duct; *e*—area of testicular septa.



Just proximal to the region of the sperm cysts there are many slender elongate cells lying transversely across the testis (fig. 20, *c*). Toward the center of this region are several long empty spaces. Further toward the base there are indications of cell degeneration (*dg. c.*) and numerous small round vacuoles.

The surrounding peritoneal sheath now closely resembles that of the adult, in that it is made up of a sheet of cells bounded by two very thin layers which are of a non-cellular nature.

The female gonad can be recognized in the early prepupal stage by its relative lack of development in comparison with the greatly enlarged testis. In the ovariole there is, as yet, no increase in size of any of the cells nor of the whole gland, and there is no production of multicelled cysts. These facts serve as the criteria for differentiating the male from the female gonads at the early prepupal stage of development.

However, the further development of the ovariole is, in some respects, quite similar to that of the testis. In this stadium the female gonads also lie in the dorsal region of the body slightly to each side of the heart. The posterior part of the gonad has a similar hollowing out of the central portion, and transverse arrangement of slender, elongate cells at the sides. In the prepupal stage the first trace of the thin non-cellular tunica propria is visible (fig. 11, *t. p.*) around the ovariole. At this time the peritoneal sheath does not yet appear to be made up of its component parts, but is merely a sheath of cells arranged in a more or less circular fashion (fig. 27).

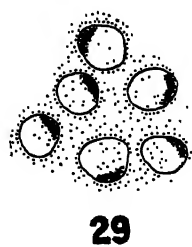
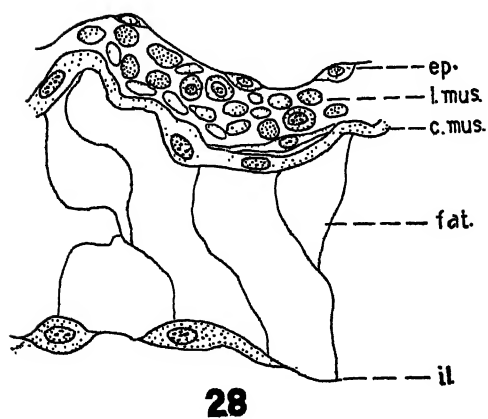
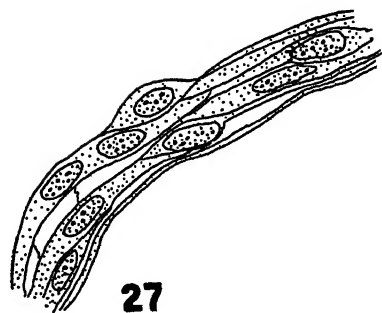
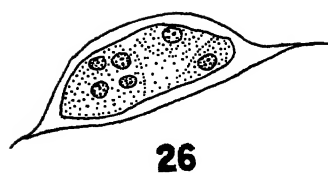
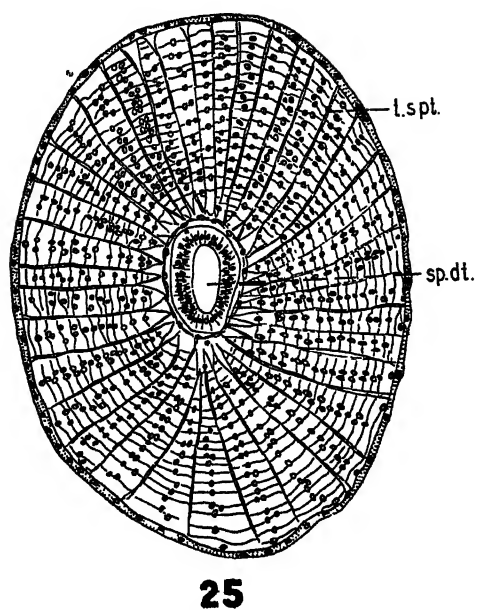
While the little knob of cells in the testis remains as an enclosed mass, apparently its counterpart has a different fate in the female. In the ovariole this little knob becomes greatly elongate, and its twists and coils slightly about the tip of the ovariole (figs. 12 and 15). Also the peritoneal sheath continues beyond the tip of the ovariole for a little way as the terminal filament.

**Pupal Stage Male:** In the early pupal stage the efferent duct has continued to differentiate, and has elongated so that it extends quite a distance from the testis proper. Then in this quiescent stadium a regular network of testicular septa is formed over the stem-like efferent canal. Originating from the region of the opening of the sperm duct in the testis (fig. 24, *c*), the longitudinal septa extend proximally along the sperm duct (fig. 24, *B*).

In a cross-section this network looks very similar to a spider's web (fig. 25). Each wedge-shaped section is made up of a ladder-like affair with a nucleus lying near the middle of each rung, and the uprights,

#### EXPLANATION OF PLATE VI

FIG. 25. Transverse section through the testis of a mid-pupal stage showing the formation of the testicular septa. *sp. dt.*—sperm duct; *t. spt.*—testicular septum.  $\times 88$ . FIG. 26. Mass of cells at the distal tip of the testis in the pupal stage.  $\times 371$ . FIG. 27. Transverse section through the prepupal ovariole showing the peritoneal sheath.  $\times 825$ . FIG. 28. Transverse section through the peritoneal sheath of a pupal ovariole. *c. mus.*—circular muscle layer; *ep.*—epithelial layer; *fat*—layer of fatty material; *i. l.*—inner layer of cells; *l. mus.*—longitudinal muscle.  $\times 825$ . FIG. 29. Several cells from the pupal ovariole near the base.  $\times 825$ .



with only a few nuclei, are arranged radially about the central sperm duct. The septa making up this ladder-like network are continuous longitudinal epithelial sheets extending about half the length of the testis. Just distal to the wide opening of the sperm duct there is a dense mass of irregularly arranged cells where the testicular septa seem to converge (fig. 31).

Later in the pupal stage the rung-like portions of the network break down and the nuclei migrate from these transverse strands to the radially arranged longitudinal septa (fig. 32). The sperm cysts, which have remained distal to the sperm duct, then migrate posteriorly passing around the edges of the dense irregular mass of cells, and begin to invade the peripheral areas between the testicular septa (figs. 30 and 32). With this invasion of cysts from distal to proximal portions, the funnel-like opening of the sperm duct is moved relatively anterior toward the tip of the gland which is the position in the adult testis (figs. 24, B and C).

As the sperm cysts migrate toward the basal portion they do not yet exhibit any sign of meiotic activity, so they are presumably still spermatogonia. At the distal tip of the pupal testis the little enclosed mass of cells is still visible (fig. 26).

During the process of pupation the testes have shifted from a dorso-lateral position to a completely ventral one (fig. 21), and are now located between the fifth and sixth abdominal segments lying with their long axes in a diagonal lateral-to-median direction.

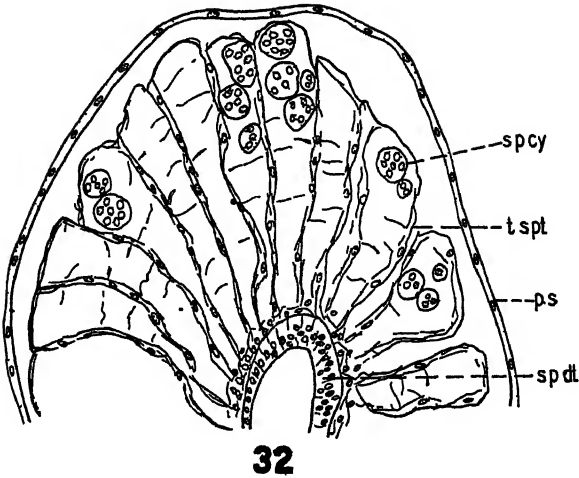
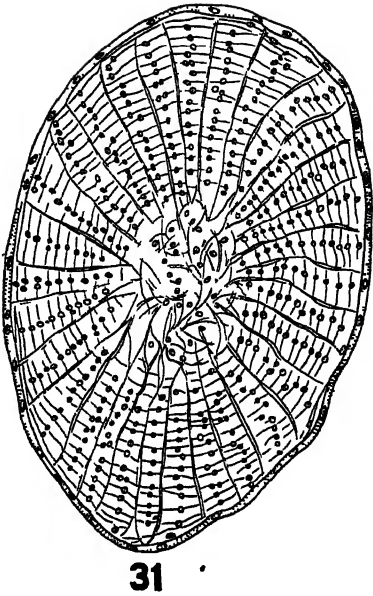
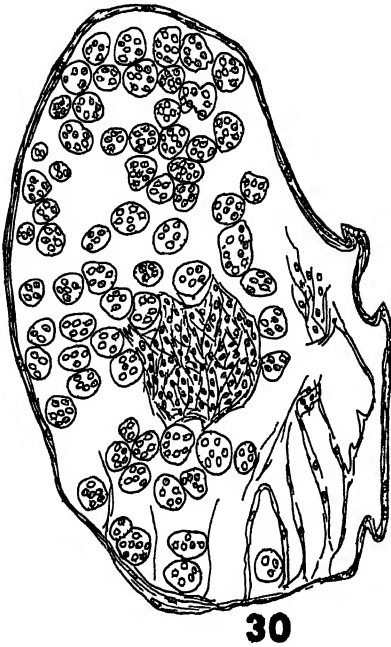
*Female:* The increase in size of the ovarioles takes place in the early pupal stage, mostly in a longitudinal direction. Like the male gonads, the ovaries have shifted from a dorso-lateral position to a completely ventral one. But, differing from the testes, the slender cylindrical ovarioles extend from the anterior end of the fifth abdominal segment to the anterior end of the seventh, where the two ovarioles join the lateral oviduct.

While the majority of the cells of the ovariole proper are quite alike in the mid-pupal stage, at the basal portion they all have most of the nuclear material clumped to one side of the nucleus (fig. 29) indicating an early phase of meiotic activity.

The peritoneal sheath in this stadium (fig. 28) begins to resemble the condition in the adult. The two muscle layers are well defined and there are traces of the outer epithelial sheath (*ep*). A large amount of fat material, and a thin layer of cells (*i. l.*) lie between the circular muscle layer and the tunica propria.

#### EXPLANATION OF PLATE VII

FIG. 30. Transverse section through the testis of a late pupal stage above the opening of the sperm duct.  $\times 86$ . FIG. 31. Transverse section through the testis of a mid-pupa adjacent to the opening of the sperm duct.  $\times 88$ . FIG. 32. Transverse section through the testis of a late pupa showing the degeneration of the transverse strands and the invasion of the sperm cysts. *p. s.*—peritoneal sheath; *sp. cy.*—sperm cyst; *sp. dt.*—sperm duct; *t. spt.*—testicular septum.  $\times 88$ .



## DISCUSSION

## ORIGIN OF GERM GLANDS

Among the genera of the order Coleoptera the time of origin of the germ glands varies greatly: from very early segregation of the germ cells as caudal pole cells (*Calandra*, *Caligrapha*, *Brachyrhinus*, and *Corynodes*), to a relatively late differentiation of the sex glands (*Tenebrio* and *Hydrophilus*).

In most of the forms where germ cells are set aside very early in development there is a dark granular region at the posterior pole of the uncleaved egg. This disc-shaped oosome stains intensely with the various hematoxylin and similar dyes and can usually be identified without much difficulty. Although many young eggs of *Passalus* were examined (some still in the ovariole) before cleavage was well under way, there was no indication in any specimen that a pole disc, or germ cell determining area was present at the posterior pole of the egg. Although several hematoxylin stains were the only ones used, if the oosome, or pole disc, were present in the egg of *Passalus*, there should have been no difficulty in recognizing it.

Also, in the beetles where the germ cells are differentiated early in development, the pole cells become separated from the blastoderm at the posterior end of the egg. According to the authors, these cells exhibit several distinct morphological characteristics which differentiate them from the other cells of the blastoderm: "large size of cells and nuclei, characteristic arrangement of sparse chromatin, and the bright staining of the cytoplasm with eosin, and Orange G." There were no cells in *Passalus* that could readily be compared to the usually distinct pole cells of some other forms.

A study of the further development of the early embryo also failed to reveal any definitely characteristic cells which might be considered as the primitive germ cells in the caudal region. In *Tribolium*, for example, these primordial germ cells were first found at the caudal portion of the germ band.

The earliest stage at which the developing gonad anlage of *Passalus* can positively be recognized as such occurs very late, in comparison with some other beetles. Identification of the sex gland rudiment depends not on the recognition of one particular type or kind of cell, but rather upon the arrangement and relations of cells in a certain region.

The best criterion, then, for distinguishing the developing sex glands is the modification in density and arrangement of some of the cells of the sixth and seventh abdominal segments of a 9-day embryo. A thick, bulging mass of cells appears in the splanchnic mesoderm of this area. At first there is no definite or regular alignment, but presently there are indications that some cells with more ovoidal nuclei are arranging themselves with their long axes following the ovoidal outline of the gonad. Although these cells do not exhibit any features which could distinguish them from other similar cells of the embryo, the fact that they have formed a dense, concentrated mass in this region, and the fact that some with ovoidal nuclei are tending to gather toward the edges of this mass clearly indicate that this aggregation of cells is actually the germ gland rudiment. It is also evident from the later history

of these cells with elongate ovoidal nuclei, that they will eventually form the external peritoneal sheath of either the testis or the ovariole.

Within the order Coleoptera we can find examples of all types of germ cell origin. Nelsen (1934b) has outlined the main general stages at which the sex cells, or the sex glands, can first be identified in insects. If we restrict his classification to only the beetles, and add some more recent examples, we find that every group except the last includes at least one genus of the order.

According to Nelsen, the first main stage at which germ cells arise is the period of blastoderm formation, the germ cells being segregated as caudal pole cells. To this group belong the following species with the author who described the origin:

1. *Calligrapha multipunctata*.....Hegner (1908)
2. *Leptinotarsa decemlineata*.....Hegner (1908)
3. *Calandra granaria*.....Inkmann (1933)
4. *Calendra callosa*.....Wray (1936)
5. *Calandra oryzae*.....Tiegs and Murray (1937)
6. *Corynodes pusis*.....Paterson (1936)
7. *Brachyhinus ligustici*.....Butt (1936)

The second stage is that immediately after blastoderm formation, the germ cells segregating from primitive blastoderm cells in the caudal region. To this group belongs:

1. *Donacia crassipes*.....Friederichs (1906)
- Donacia crassipes*.....Hirschler (1909)

The third period occurs shortly after the germ-band, as such, is demarcated from the blastoderm, but before segregation of the inner layer is initiated. The germ cells are segregated from the primary ectoderm in the caudal portion of the germ-band. An example of this group is:

1. *Tribolium confusum*.....Hodson (1934)

The fourth stage of germ cell origin is that during the period of the inner layer and mesenteron segregation, but before the formation of the coelomic sacs:

1. *Tenebrio molitor*.....Saling (1907)
- (Nelsen puts the species in this group, but Saling admits that the gonad anlage cannot be identified with certainty as early as this stage.)

The fifth period occurs after the coelomic sacs have formed. The germ cells are derived, or associated with—when first detected—the coelomic sac mesoderm. Examples are:

1. *Hydrophilus piceus*.....Heider (1889)
  - Hydrophilus piceus*.....Graber (1891)
  2. *Lina* sp.....Graber (1891)
  3. *Tenebrio molitor*.....Saling (1907)
- (Probably this is an example of group four.)

The sixth period occurs during post-embryonic development. No Coleoptera are represented in this group.

Inasmuch as the gonads of *Passalus* arise from the splanchnic mesoderm and are distinguishable only relatively late in embryonic development, it could properly be included in the fifth group. It is



interesting to note that *Hydrophilus*, the most closely related to *Passalus* of the beetles studied, has a quite similar method of origin of the germ glands, and also belongs to this group. On the other hand, *Tribolium* and *Tenebrio*, members of the same family, belong to different groups. One would expect to find that the more closely related forms would fit into the same groups.

#### DEVELOPMENT OF THE GONADS

In spite of the fact that the gonads apparently arise relatively late in development, each of the anlagen divides into two parts almost immediately after its formation (fig. 3). This is in contrast to *Calandra*, for example, where the glands are not divided into the two component parts until after eclosion and the larval stage has been attained.

The shape of the gonad rudiment undergoes a series of modifications (fig. 8) from an ovoidal mass in the 9-day embryo (A), to a comet-shaped gland (B) in a 10-day embryo and to the beginning of a Y-shaped gland (fig. 9, A) slightly later. From this period on, the division into the component parts is continued until the larval stages are reached and the pair are joined only at the proximal, basal region (fig. 10, A and B).

The formation of the little ball-like knob of cells at the distal tip of the gonad rudiment is quite interesting. At least in the male, neither its morphology in the adult, nor its method of formation gave any hint as to its significance or probable function. On the other hand, it apparently has a different fate in the female. But the consideration of this structure will be postponed until after the topic of sex differentiation.

#### SEX DIFFERENTIATION

The period at which the developing gonad can be identified as an ovary or testis varies somewhat in the different beetles that have been studied. In *Tenebrio*, Saling (1907) indicated that sex differentiation occurred shortly before the close of the embryonic period. The testis could be recognized as such because, at this time, it had formed six diverticula, whereas the ovary had developed twelve.

Hegner (1909, 1914) recorded that in *Calligrapha* sex differentiation took place some time before the larval stage was reached. The sex of the embryo could be determined by the shape of the germ glands; those of the male became dumb-bell shaped, but the female organs retained their earlier pear-shaped form, and began to acquire terminal filaments. Then there ensued a period of activity during which a large number of ovarian tubules developed in the female, and testicular follicles appeared in the male.

Hodson (1934) pointed out that sex differentiation in *Tribolium* occurred just before hatching time, or immediately after eclosion. In the male six tubules, which ultimately comprised the testicular follicles, labeled the gonad as a testis; while if there were eight protuberances occurring in double rows of four on the inner lateral surface of the gonad, the female gonad was indicated.

In *Calandra*, Murray and Tiegs (1935) maintained that sex differentiation took place at an early larval stage. The ovaries enlarged in the young larvae, and became constricted into two pyriform bodies. The male gonad in larval life consisted of a single pair of testes dorsal

and behind the mid-gut. The ovaries could also be identified by mycetocytes, which were lacking in the testis.

In *Leptinotarsa* Wieman (1910b) indicated that at the close of the larval period the testis resembled a single ovariole.

It is quite evident, then, that in the different beetles studied the criteria for sex differentiation are by no means identical. In *Passalus* sex differentiation obviously occurs at the beginning of the prepupal stage. In the male individual there is a rapid increase in the size of the whole gland. Within the testis itself there is a considerable enlargement of some of the cells and the beginning of enclosure of spermatogonia into the multicelled sperm cysts (figs. 20 and 23). At a corresponding stage the ovarioles still remain slender and cylindrical, but shortly begin to elongate. Within the gland itself there is as yet no enlargement of individual cells, and of course no formation of sperm cysts.

In the other beetles studied the shape of the developing gonad often gave a hint as to whether the gland would be a testis or an ovary. But in *Passalus*, since both the male and female gonads have a similar Y-shaped arrangement, sex differentiation must depend upon a difference in the cells rather than in the shape of the glands themselves. Because the testis seems to differentiate somewhat earlier than the ovariole, it is possible to identify the male gonad in the early prepupal stage by the sperm cysts and enlarged spermatogonia. The cells of the ovariole do not begin to enlarge until much later in development.

#### FURTHER DEVELOPMENT OF THE GONADS

In even the late embryonic stages and in the early larval stages there are many cells that seem to be undergoing degeneration. Although a careful and detailed cytological study of this process was not made, several features could be observed. This degeneration probably takes place first by a clumping or condensation of chromatin material in the nucleus. Then this darkly staining condensed material is liberated between the other cells of the gonad. As more and more cells undergo this process there is a tendency to produce larger and larger masses of dark material in the form of globules. There are indications that this process occurs most extensively near the basal and central portions of the developing germ gland. Thus, the cavity of the efferent canal is formed by a hollowing out of the basal or proximal portion of the gonad.

Wieman (1910b) regarded a similar degeneration of cells in *Leptinotarsa* as a process of supplying nourishment to the germ cells, and looked upon these degenerating cells as "nurse cells." In *Passalus*, however, I believe it is primarily the method by which the efferent duct, or at least the lumen, is formed. That the germ cells are actually receiving a nutritive substance from the degenerating cells could not be demonstrated with the material at hand. The fact that the disintegration in the indifferent gonad commences long before the efferent duct is definitely formed is, perhaps, the only indication that such a nourishing process might actually be taking place.

When the degeneration has become quite wide-spread in the early prepupal stage, the peripheral cells at the proximal basal part of the gonads transform into tall columnar epithelial cells, and form the walls

of the sperm duct or lateral oviduct, as the case may be. However, the sperm duct arises much earlier than does the efferent duct in the female.

In the late prepupal stage the inner non-cellular tunica propria can be definitely recognized for the first time (fig. 11). It is clear by its location and appearance that it is a secretory product of the cells of the ovariole proper.

While the fate and significance of the little ball-like knob of cells at the tip of the gonad is an enigma in the testis, this same structure in the ovariole has an interesting subsequent history. In the prepupal stage the knob of cells begins to elongate and twist slightly about the tip of the ovariole (figs. 12 and 15) ultimately forming the spiral, apical nutritive chamber.

The function of the terminal filament is somewhat varied in the different insects. Wieman (1910a) recorded that it developed earlier in *Leptinotarsa* and that it aided in the upward migration of the embryonic gonads toward the dorsal region of the body. In other cases, it apparently serves as an anchor, or means of attachment for the adult ovarioles. Because of the late development, in the prepupal stage of *Passalus*, its possible significance as an embryonic attachment organ is, of course, eliminated. Even though it arises late, its function as a suspensory structure or means of attachment in the immature forms also is quite plausible. As there is a considerable shifting in position of the ovarioles during the quiescent stadia, it is probable that the terminal filament plays an important role in this process. Its significance later, however, seems to be diminished, since the fat-body and the numerous tracheae penetrating the ovarioles also tend to support the gonads in the imaginal stage.

By far the most striking and unusual feature of the development of the gonads is the formation of the testicular septa in the pupal testis. Since this is correlated with the unique morphology of the adult testis, there is no such similar process described for other beetles.

Along with the formation of the septa there has occurred an irregular massing of many cells over the open funnel-like portion of the sperm duct (fig. 30). This mass of cells prevents the migrating cysts from going into the sperm duct in their as yet immature condition. The fact that the sperm cysts always first appear toward the peripheral portion when invading the region of the testicular septa, and the fact that they are never seen migrating through the mass of cells indicate that this epithelial arch of cells serves both in the pupa and in the adult in the same fashion. That is, it prevents the immature sex cells from escaping into the sperm duct.

Although a similar plug of epithelial cells is commonly found in the ovariole of many insects, including *Passalus*, it is quite unusual to find it also present in the testis. But, comparing the epithelial arch in the testis and the epithelial plug in the ovariole, it is obvious that they have precisely the same significance in preventing the sex cells from escaping prematurely.

While the genital cells in the testis begin their maturation in the early prepupal stage, the egg cells do not show any signs of meiotic activity until the mid-pupal stage. At the basal portion of the ovariole there are many cells with very clear nuclei and the chromatin material

clumped to one side against the nuclear membrane (fig. 29). This probably is the synizesis stage, indicative of the fact that meiotic activity has definitely begun.

The further development of the egg cells, the formation of follicle cells, and the formation of the epithelial plug from these latter cells occurs during the late pupal stadium and early imaginal stage after metamorphosis.

In the pupal stage the peritoneal sheath of the ovariole differentiates into its component parts (fig. 28). However, the significance of the fat material and the inner layer of single cells could not be determined.

#### SUMMARY

1. The egg of *Passalus* does not possess an oosome, or germ cell determining area, at the posterior pole of the egg. No typical pole cells were found to segregate from the blastoderm or caudal region of the early embryo.

2. The gonad anlagen arise from the splanchnic mesoderm of a nine-day-old embryo, at which stage the lateral edges of the germ-band have grown about one-third the way to the dorsal midline. A slightly thickened dense mass of cells appears in the region of the sixth and seventh abdominal segments of each side.

3. Almost immediately each sex gland anlage divides into two parts at the anterior end, producing a Y-shaped structure while the surrounding cells consolidate to form the beginning of the outer enveloping peritoneal sheath.

4. The arms of the Y-shaped gonad elongate and form at the distal tip a little ball-like knob of cells. Near the base and central portions of the glands, some of the cells begin to degenerate, and this process ultimately results in the formation of the lumen of the efferent ducts.

5. During larval life the structure of the gonad is not appreciably altered, but there is some gradual increase in size and further degeneration of cells in the basal portions.

6. Sex differentiation occurs during the early prepupal stage. The male gonad increases tremendously in size, while many of the cells in the anterior part of the testis have also greatly enlarged. In the proximal region the spermatogonia become enclosed in multicelled sperm cysts.

7. The female gland can be readily distinguished from the testis at this stage by the fact that the ovarioles do not undergo such a rapid increase in size just yet, and no multicelled sperm cysts are present.

8. Also in the prepupal stage the basal portion of each gonad hollows out by the degeneration of central cells, while the peripheral ones have transformed into the tall columnar cells that compose the wall of the efferent duct. The investing sheaths of both the testis and the ovariole can be identified in the late prepupal stage. The tunica propria is probably secreted by the cells of the egg tube. The peritoneal sheath of the ovary extends anteriorly as the terminal filament, and this quite likely acts as a means of attachment in the quiescent stadia, at which time there is a considerable shift in position of the ovarioles.

9. The fate of the little ball-like knob of cells at the distal tip of the gonad varies according to the sex of the individual. In the male it remains in the adult as an inconspicuous little mass of cells enclosed

by a non-cellular envelope. In the female it becomes greatly elongate and eventually forms the spiral-like tip of the germarium serving as an apical nutritive chamber.

10. During the pupal stage the testicular septa form in the testis and the spaces between them are invaded by the multicelled sperm cysts. With the growing of these septa from the distal to the basal portion, the sperm duct appears as a funnel-shaped canal extending nearly the whole length of the testis, and approximates the position in the young adult male.

11. In the female at the pupal stage early meiotic phases are visible in the cells near the base of the ovariole, and the whole gland is histologically similar to that in the newly metamorphosed imago.

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REVIEW OF THE NEW WORLD SPECIES OF HIPPODAMIA DEJEAN (COLEOPTERA: COCCINELLIDAE), by EDWARD A. CHAPIN, 39 pages, 22 plates, June 14, 1946. Smithsonian Miscellaneous Collections, Vol. 106, No. 11.

The brief introduction states that much more collecting and study will be needed to clarify the taxonomy of this genus, but since the review is based on the study of more than 11,000 specimens of the few included species it must be regarded as an important foundation.

Following the introductory material the genus is described in detail and the species and subspecies are taken up individually. The treatment is not uniform. In some cases it includes fairly extensive comments on specific characters and in some cases summaries of the material studied. Type localities and general distribution are cited. The species are not keyed. The reviewer concludes that the end sought is a concise expression of the points which are most significant to coleopterists who are already acquainted with the genus.

Illustrations include genitalia, figures of adult maculation and maps showing distribution. All are expertly drawn and reproduced. It is unfortunate that our national institutions find it necessary to print figures on both sides of translucent paper, but possibly this economy is unavoidable.—A. W. L.

# REPORT ON THE STATUS OF THE ENTOMOLOGICAL COLLECTIONS IN CERTAIN EUROPEAN MUSEUMS, 1945

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On 31 May 1945 Dr. C. F. W. Muesebeck, Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine, Washington, D. C., addressed a letter to me saying: "We have been much concerned about the fate of entomological collections, particularly those containing type material, in the devastated countries of Europe—Berlin, Hamburg, Kiel, Stettin, Munich, Bonn, Brussels, including the Congo Museum at Tervueren just outside of Brussels, Vienna, and Budapest. . . ."

This letter finally reached me on 28 August 1945. Because this request had to do with information, scientific study and education, I immediately contacted my commanding officer and asked permission to make the survey of the museums. The request was granted. The Army provided motor, rail, and air transportation. The following is a brief summary of my observations:

PARIS, FRANCE: Musee Nationale D'Histoire Naturelle was unharmed. The Germans did not molest the collection or disturb the personnel of the museum. There are 10 specialists and 10 helpers in entomology. The insect collections are said to contain 15,000,000 specimens, 200,000 of which are types. The entomological library is in excellent condition.

Dr. Lucien Berland, specialist in Hymenoptera, assistant director of the Museum, in charge of insect collections, stated that the scientific journals continued to be published during the war, but, because of the paper shortage, the number of pages in each issue was greatly reduced.

A private collection of Lepidoptera belonging to Albert Zerkowitz, formerly of Paris, now of New York, was stolen by the Nazis in August 1942, together with books, art objects, and furniture.

RENNES, FRANCE: This museum formerly contained a good collection of insects, especially Coleoptera, and Lepidoptera. A few years before the war the Deutsches Museum, in Berlin, offered 1,000,000 marks for the Oberthur collection of Lepidoptera, but the French refused to sell it. Some people think the collection was stolen during the war, while a few think that one of the French curators evacuated it to a safe place.

LOT, FRANCE: Le Carrid par Dovel. Nothing definite could be learned as to the safety or whereabouts of the microlepidoptera collection of Chretien. Other collections in this little museum were evacuated to safety.

LONDON, ENGLAND: British Museum of Natural History, South Kensington, suffered a few random shots from strafing by the German



planes, and V-bombs shattered the glass from many windows and some of the exhibition cases. The study collections had all been stored in the cellars and basements or evacuated from London, mostly the latter.

Mr. Barnett, entomologist, showed me the collections that had been returned to the museum, and said others were coming in as fast as the limited staff could handle them. He also said that the British Museum was sending a man for just such a survey as I was making.

Museum publications were issued during the war, but the size and frequency of issue was not up to prewar standards.

LIVERPOOL, ENGLAND: Incendiary bombs landed on the Liverpool Museum and burned it out. Most of the collections had been evacuated to southwest England, and were thought to be intact.

BRUSSELS, BELGIUM: Musee d'Histoire naturelle de Belgique was not damaged. Prof. Dr. Van Stroelen A. d'Orchymont, curator of Entomology, showed me through the Museum, and told me that shortly after the beginning of the war the insect collections were moved to the basement of the main building. The exhibits were left in place, and in October 1945 all insect collections had been moved back to their proper places. The collections are strong in insects from the East Indies.

The museum publications continued uninterrupted, the size and frequency of the issues being the same as before the war, and there was no interference by the Germans. Andre Janssens is collaborator in entomology.

TERVUEREN, BELGIUM: Musee du Congo Belge, H. Schontedry, director, and L. Burzeog, entomologist, reported that although some glass was shattered, all exhibition cases and the collections were unharmed.

Publications were reduced in size; the issues were less frequent during the war. Insect collections were stored in well-protected basements, but are now back in their proper places in the museum laboratories and cabinets.

AMSTERDAM, HOLLAND: The insect collections, as well as many others, were evacuated to safe places, and have now been returned to their cabinets in the Museums. There was no damage.

LEIDEN, HOLLAND: The Royal Museum was damaged by bombs, but most of the damage was confined to the exhibition cases in one of the wings of the building. The insect collections had been stored in the basement, a few were evacuated, and all are now restored.

MAASTRICHT, HOLLAND: Museum of Natural History, Dr. Wilhelmina Van de Geijn, curator, had, prior to July 1943, a remarkably good collection of ants, which had been collected and "tended" by the R. P. Erich Wasmann, S. J. The collection was for many years kept in Valkenburg where Wasmann lived and served his people. Wasmann died in 1932 and Father Schmidt, a former student of Prof. Dr. Reichensperger, of Switzerland, now of Bonn, Germany, succeeded him as priest and also as curator of the ant collection. The entomological collection was kept at the Ignatius College at Valkenburg, but when Schmidt was called to Germany, his original home, the collections were placed in the Museum at Maastricht, where they could be properly housed and cared for.

In July 1942, Schmidt asked the German entomologists in Berlin to

get the collection and bring it to Berlin so that he could continue working on it. Schmidt was not in Berlin, however, nor had he been there. Prof. Hans Bishoff, of Berlin, had shown great interest in the collection and visited Maastricht several times in attempts to get it. Sensing trickery in Bishoff's visits, the Maastricht curator hid the collection in the basement of the Rathhouse, and its whereabouts was known to only a few. Of course the Nazi Bourgeoismeister, Peeters, knew of the plan. He disclaimed any knowledge of its whereabouts and on several occasions tried to dissuade Bishoff from taking the collection. The S. S. troopers and Bishoff finally got hold of the assistant bourgeoismeister, D. Th. A. M. Copray, and "persuaded" him to reveal the location of the collection which they removed to Berlin.

While stationed in Maastricht, as Typhus Control Officer for G-5, Ninth U. S. Army, during the winter of 1944-45, I became personally acquainted with many of the citizens of the little city, including the museum curator, Dr. Van de Geijn. Likewise I learned of the loss of the collection, and the circumstances surrounding its loss. When I was reassigned to make the museum survey, I set out to find the Wasmann collection and restore it to the Museum in Maastricht. On Wednesday, 19 September 1945, I reached Berlin. The following morning I located Prof. Bishoff in the Deutsches Museum at 43 Invaliden Strasse and shortly after was able to get him off on ants. He showed me the Wasmann collection, which, he explained, had been carried to Berlin for protection only. Some of the specimens were in the basement of the Museum, and others were in a vault of the Central Landschafts Bank, two floors below the ground, and across the street from Hitler's Reich Chancellery.

The insect collection and the entire library of some 50,000 titles, and photographic equipment, was returned to Maastricht on Saturday, 29 September 1945. One cabinet of about 20 trays of Phorides was missing, but later was found in Waischenfels (Oberfranken), about 50 miles southeast of Bamberg, where a branch of the research department of Ahnenerbes, under the direction of Heinrich Himmler, was maintained. The cabinet was returned to Holland on 27 November 1945, thus completing the return of the entire collection to its rightful owners. This was the first stolen "loot" returned to *any* of our allies, and the *only* property recovered from the Russian sector of Germany.

The shipment filled 83 crates and boxes, and required an entire ten ton trailer truck to move it. The lot included 310 insect trays, 100 large bottles (each filled with small vials) containing alcoholic specimens, 2 boxes of lantern slides, 4 boxes of photographic equipment, 500 related letters, 50,000 entomological publications, and several unpublished manuscripts dealing with ants, ant parasites, and guests of termites of all countries. Wasmann's more general papers were along the line of animal psychology and the theory of evolution serving directly the "Christian" view of life.

#### GERMANY

Three cities claim to be the real entomological center of Germany, in fact of all Europe: Berlin, Dresden, and Munich. All three cities were bombed very heavily and their museum buildings destroyed. The col-

lections are in fair to excellent condition, but are not together in any one place. It is hardly probable that the collections will be assembled in their respective localities for some time to come, for there are no buildings large enough to accommodate them in or about the cities mentioned.

AUGSBURG, GERMANY: The museum and most of the collections were destroyed.

BAMBERG, GERMANY: The townspeople reported that the collections were saved when the museum building was destroyed, but the curators are away, whereabouts unknown.

BERLIN, GERMANY: The Deutsches Zoologisches Museum was badly bombed, but not totally destroyed. Most of the insect collections were evacuated to various communities in Mecklenburg, and are now safe. Except for six boxes of books, the entomological library is also safe, having been stored in the Museum basement and in Rostock.

The staff of entomologists employed at the Deutsches Zoologisches Museum is as follows: Prof. Dr. Hans Bishoff<sup>1</sup>, director and curator of Hymenoptera; Prof. Dr. W. Ramme, curator of Orthoptera; Prof. Dr. E. M. Herring, curator of Diptera and Lepidoptera; Dr. H. Hedicke, curator of Hemiptera; Dr. K. Delkeskamp, curator of Coleoptera.

All of the material collected on the Schafer Expedition to Tibet, consisting chiefly of Lepidoptera, is safe.

The collections of the Deutsches Entomologisches Institut der Kaiser Wilhelm Gesellschaft (Dahlem) were saved by evacuation in 1943 to Blucherhof Post, Vollrathruhe, Mecklenburg.

The library was not moved until July 1945, after the American troops requisitioned the Entomological Institute building at 20 Grossler Strasse, Berlin. Because of the slowness of the Germans in removing the books from the building, American soldiers destroyed, by burning, approximately ten per cent. Prof. E. M. Herring, First Trustee of the Deutsches Entomological Institute, saved the other nine-tenths. All insect collections and library will be returned to Berlin when a suitable building is available.

In addition to the director, Dr. Hans Sachtleben, the Institute had a dipterist, Dr. W. Henning, and a coleopterist, R. Korschepsky. Dr. W. Horn, coleopterist, died in 1944.

BONN, GERMANY: Zoologische Forschungsinstitut and Museum Alexander Koenig, Reichsinstitut, Dr. Adolf Von Jordons, director, Prof. Dr. Reichensperger, entomologist, was practically untouched in the bombing, but every precaution had been taken to hide the insects collection in a safe place. The other University buildings were bombed and mostly destroyed.

Part of the collection of Arctiidae and Saturniidae had been loaned to the Munich Museum prior to the war, but they were evacuated with the Munich materials and saved.

One volume of Meigen's original colored plates of insects is in the Bonn University Library, and is safe in the home of Prof. Reichensperger.

This museum contains the famous collection of Chinese insects collected by Dr. How, and in good condition.

<sup>1</sup>Prof. Bishoff is the man who personally supervised the looting of the Wasmann collection from the Museum of Natural History, Maastricht, Holland. Read the Maastricht notes in this article.

BREMEN, GERMANY: Deutsche Kolonial and Uebersee Museum was located near the railroad station and was completely destroyed during the air raids. Most of the collections had been removed to the country prior to the bombing of the city. The insect collection was not important, but the collection of fish and marine animals is considered very good. The library which was also moved to the country was saved.

Dr. Amsel is the entomologist. Dr. C. Fr. Roewer, formerly director of the museum, is still in Bremen. He was successful in saving his collection of Arachnids.

BRESLAU, GERMANY: The Museum contains the Wiscott collection of hybrids and monstrosities. Prof. Pax is the zoologist. Nothing definite is known about the insect collection, but it is thought to be safe in the nearby countryside.

DARMSTADT, GERMANY: The private collection of Prof. Traudt of Noctuidae and American butterflies was destroyed.

DRESDEN, GERMANY: The museum building was destroyed. The most important entomological collections were evacuated to the countryside and stored in out-of-the-way places, hotels and old castles. These were saved; others were lost. Prof. Heller is the chief entomologist. The collections are rich in Coleoptera, especially Coccinellidae and Curculionidae.

The private collection of Staudinger, composed of Lepidoptera and Coleoptera, was reported destroyed, but as a matter of fact, they were merely evacuated to a small village and are now safe. The Kotesch collection of Lepidoptera was evacuated to Aussig and saved. The Röber collection of butterflies of the world has not been located, but is thought to have been evacuated to the countryside.

EBERSWALDE, GERMANY: The Forest Institute, near Berlin, has a fine collection of forest insects, including the classical collection of Ratzesburg, which was collected at least 100 years ago. The present entomologists are Wolff and Krause. The collection is safe.

ERFURT, GERMANY: This museum contains a general collection of local insects and is safe. Dr. Rapp is the entomologist.

FRANKFURT, GERMANY: The Senckenberg Museum buildings were destroyed, as were the exhibits, but the collections had been evacuated to some forty odd "camps" within 60 miles of the city. Only one "camp" or storage place was destroyed. The insect collections, over 3,000,000 specimens, were stored at Oberlais and Vogelberg, and are now in good condition. The famous collection of human embryos, 500 specimens, is also safe. The Mollusca collection, said to be the greatest in Europe, 2,000,000 specimens, is safe. Prof. Dr. Hans Theodor Reuling, geologist, is director of the museum. Dr. Franz is chief entomologist.

Scientific journals and reports were published throughout the war, until March 1945, at which time the paper shortage and the oversupply of aerial bombs became very marked.

HAMBURG, GERMANY: The Naturhistorisches Museum was completely destroyed, but many of the collections, including most of the insects, were saved by having been removed from the museum prior to the bombing of the city. They were stored in a railroad tunnel.

The private butterfly collection of Warnacke is all right. I did not see Dr. Dunker, the director, but understand from his friends that he is in good health and planning to procure a temporary, yet suitable, building to house the museum study collections. Most of the exhibits were destroyed.

HEIDELBERG, GERMANY: No large or important insect collections are here, but the private collection of Coleoptera of Geh-Rote-Bosch is safe. Heidelberg was not bombed, so the entire city and the University were unharmed. Most of the buildings, however, are now used by the U. S. Seventh Army.

KIEL, GERMANY: Thaulow Museum of Natural History was completely destroyed, but prior to its destruction, the Fabrician collection of insects was removed from the museum to a building in the country. This collection was assembled from 1775 to 1801 and at present is in care of Dr. Schröder, who lives in Heickendorf, a few miles from Kiel.

MUNICH, GERMANY: The Zoologische Museum and most of the zoological collections were destroyed. Prof. Dr. Hans Krieg is director of the Zoologischen Sammlung, and Walter Forster is curator of insects.

The insect collections were divided into three groups and evacuated to: (1) a hotel at Ohlstadt, (2) a castle at New Egling, and (3) a monastery at Tolling, all within 70 miles of Munich.

The total collection of insects included 350 cabinets, totalling 15,000 cases. A very fine and large library of entomological works accompanied the insect collections to their respective hiding places. All were saved, most in good condition. The collections are strongest in Lepidoptera, Coleoptera, Hymenoptera, and Diptera.

The study collections of Arctiidae and Saturniidae from the Bonn Museum are included in the Munich collections since they are on loan to that museum.

Several private entomological collections in Munich are of importance, hence a few notes on each of them:

*George Frey*: The largest collection of Coleoptera in Europe. This museum was evacuated to several places nearby and was saved.

*Ludwig Osihelder*: Microlepidoptera collection. Evacuated to Poland and said to be safe.

*Ernest Pfeiffer*: Palearctic butterflies (largest private collection in Europe) evacuated to Ohlstadt. Now safe.

*Frank Daniel*: Palearctic Lepidoptera evacuated to Ohlstadt. Saved and in good condition.

*H. W. Tauber*: Fine collection of Hemiptera, but he failed to heed the invitation to evacuate it. Bombs destroyed his home, insect collections, and library.

The publication of entomological journals in the Munich area flourished during the war; in fact, the number of pages was often increased and the works of French entomologists were included. Colored plates were used more freely than ever before. This while the number of entomological journals published throughout Germany decreased about fifty per cent.

The Amerika Institut, said to be a Rockefeller Foundation project for the exchange of scientific periodicals, books, etc., was destroyed in November 1943. Some of the staff are still "carrying on" in makeshift offices.

STETTIN, GERMANY: The Naturkundemuseum was destroyed. The insect collections were stored away in the cellar. Their condition will not be known until the debris is removed from the ruins of the building. The entomological collections contained the Microlepidoptera belonging to E. D. Harring and the Mallophaga collection of Dr. Doehrn. A. Kaestner was director of the museum.

STUTTGART, GERMANY: The museum building was destroyed, but the insect collections were saved. The collection of Diptera, Coleoptera, and Lepidoptera is very good. Dr. Lindner is the entomologist.

WURZBURG, GERMANY: The museum was destroyed as were most of the other buildings in the city. There was no special collection of insects, but a general collection, with emphasis on Hemiptera. Dr. Surger served as entomologist and he managed to save most of the insect collections.

VIENNA, AUSTRIA: The magnificent Naturhistorisches Museum building was erected during the period 1888-1894, and houses all of the zoological, botanical, and geological collections. Dr. K. Holdhaus is director of the Zoological Section of the Museum. His special field is Coleoptera. Dr. Franz Maidl is curator of Hymenoptera, and Dr. Max Beier is curator of Diptera. Even though the entire museum is understaffed, the collections are in fine condition, especially the entomological collections, the most important of which are:

Diptera collection of Brauer, Schiener, and Bergenstamm; the Coleoptera collection of Eppelsheim (Staphylenidae), Hauser (Asiatic beetles); and Hampe and Redhenbacher. The Coleoptera collections are regarded as historically important.

The entomological publications, "Coleopterologische Rundschau," were issued irregularly during the war. The Museum issued several small publications from time to time, but no "Memoirs" or large publications were undertaken. The Museum also continued its "Annalen des Naturlist," but on a reduced scale.

After the war got under way, the scientists took every precaution to see that the collections, especially the types, were evacuated to safe places in the country or in the cellars of the more substantial buildings in the city.

Compared with the German cities, the destruction in Vienna was small. Yet a few direct hits by bombs and artillery destroyed many important buildings. The Anatomical laboratories of the University Medical School received a direct hit, while heavy explosions near the Natural History Museum shattered many of the glass windows. None of the entomological collections was harmed in the least, but a portion of the botanical collection, the conifers and Caryophyllaceae, were destroyed.

According to Dr. Holdhaus, the scientific staff of the museum was not restricted or hindered in their work, either by the Germans or by the "liberators."

LINZ, AUSTRIA: The Natural History Museum at Linz is small, but the collection of Microlepidoptera is considered good. It is safe. Dr. Von J. Klimesch and A. D. Ver Donair are the entomologists.

SALZBURG, AUSTRIA: Haus der Natur houses the natural history collections. Director Prof. Dr. Edward Paul Tratz, said by his colleagues to be an ardent Nazi (Schutz Staffel), could not be located. The collec-

tion of local mammals, birds, and insects is good. They are all safe. There is no regular entomologist connected with the museum.

**BUDAPEST, HUNGARY:** The Ungarisches Nationalmuseum, founded in 1802, was not visited, but word from the entomologist, Dr. J. V. Szent-Ivany (Lepidopterist) indicated that the insect collections are in good condition. They were evacuated to safe places prior to heavy shelling of the city.

The Reitter collection of Coleoptera is considered very good, the Lepidoptera fair, and the *Biro* collection of insects from New Guinea is excellent.

**PRAGUE, CZECHOSLOVAKIA:** The Nationalmuseum collections are safe and in good condition. The Coleoptera collection is reported to be very good. The classical and historical collection of Lepidoptera assembled by Nickerl is intact. Dr. Jon Obenberger is entomologist of the museum.

**COPENHAGEN, DENMARK:** Zoologisk Museum, located at Krystalgade 27, adjoining the University of Copenhagen and a part of it, was started in the 16th century. The present building was erected in 1870. A new and modern building is now contemplated. Dr. Louis Bohr is Director of the Society of Science, hence the director of the museum.

Dr. Prof. Louis Bovien is chief of the Quarantine Division. S. L. Tuxass, entomologist, is working on the Collembola. Dr. S. V. G. Larson, entomologist, is working on the larvae of Coleoptera and Lepidoptera, and has countless numbers of alcoholic specimens. The collection of Coleoptera larvae is especially good, and dates back to Prof. J. C. Shidte, the first great Danish entomologist, who procured most of the collection from 1860 to 1870.

The entomological publication, "Entomologiske Meddelelser," was printed regularly during the war, but was not mailed outside of the occupied countries.

When the war started, all type specimens were removed to safety in the surrounding country and none were lost. The Germans, although occupying all of Denmark, did not interfere with the museum or its workers. A few Windows in the museum were broken by the flak from exploding shells in the vicinity, but no real damage was done to the exhibitions or the study collections.

**AARHUS, DENMARK:** The Naturhistorisk Museum, on the campus of the University of Aarhus (in Jutland), is of no great importance, but is used in connection with university classes in various courses in natural history. The German soldiers did not molest it in any way.

**OSLO, NORWAY:** The Zoologisk Museum has a good collection of Arctic mammals, birds, and insects. There is also a fine collection of South Polar birds, and a fairly good collection from the Galapagos Islands. The Norwegian insect collection is very good, especially the Coleoptera and Lepidoptera.

Prof. Dr. Lief Reinhardt is the entomologist. His specialty is Diptera—mosquitoes, yes, mosquitoes in Norway and lots of them.

They have a good collection of Australian Coleoptera.

All of the types were evacuated from the museum and hidden in the country near Oslo. This applied to all the museums in the city—art, archaeology, industrial, geologic, etc. In fact, the Germans took over

some of the museums, near the center of the city, for war offices, and in so doing they became impatient over the slowness with which the buildings were vacated and made ready for them. Some of the industrial and machine exhibits were destroyed by the Germans.

"The Norsk Entomologisk Tidsskrift" was published throughout the war. Number 3 and 4 of Volume VII came from the press in October, 1945.

During the German occupation the Norwegians were compelled to print many articles in their journals in German.

The Zoologisk Museum, as are the other museums in Oslo, is a part of the University of Oslo, but it is located across the city from the academic center of the University.

STOCKHOLM, SWEDEN: At the Naturhistorisk Riksmuseets, Prof. Dr. Olaf Lundblad is head curator of insects. Dr. Rene Malaize is assistant entomologist, and Prof. Rendahl is curator of vertebrates.

The museum building, a large granite structure, was erected in 1916, but the collections date back to the early 18-hundreds.

Prof. Lundblad is a specialist on water mites, and has a very large and important collection from all parts of the world.

The collection of Swedish insects, in fact all Swedish fauna, is very complete. There is a fairly good collection of Coleoptera of the world. Many of the types of the French collector Cherevolat are included. The Lepidoptera collection is mostly old world material, but rather ordinary.

In 1941 and 1942 it began to look as though the Germans would "take over" Sweden. Accordingly, all type specimens of insects, and other groups as well, were evacuated to safety in the nearby country. They are now back in place in the museum. Publication of "Entomologisk Tidsskrift" (Journal of Entomology), begun in 1880, was continued without interruption throughout the war. This Journal is not a museum publication, but of the Entomological Society in Stockholm.

The Agricultural Experiment Station and the Forest Laboratories and Experimental Forest Farms are located on the outskirts of Stockholm. They have insect collections, and were not disturbed by the war activities.

UPSALA, SWEDEN: A little side trip to Upsala proved very interesting, because of the presence of Upsala University and Linnes Hammarby.

The University Museum of Zoology houses the University Department of Zoology as well as the museum. The museum is chiefly for teaching purposes and is the conventional synoptic type, but very good for comparative anatomy—skeletons galore! Entomology is a minor affair, but present. N. V. Robsten is professor of comparative anatomy and histology. S. Horstadius is assistant professor of zoology, and Dr. Bengt Hubendick is assistant zoologist, specializing in Mollusca.

The University of Upsala Library is very interesting, because it contains many editions of Linné's 176 titles. In fact, there is a complete section set aside as Linné's room. In it Fil. Dr. Arvid H. J. Uggla, the chief librarian of the University, has gathered an enormous quantity of materials—books, booklets, portraits, letters and personal belongings of Linné. Dr. Uggla is the outstanding biographer of Linné.



About ten kilometers from Upsala is Linné's Hammarby—his summer home for twenty years, 1758–1778. The house, garden, the little museum and workshop, precisely as it was left by Linné, sits on a slope at the edge of a beautiful grove of evergreen trees, many species of which were introduced by Linné. The garden contains many exotic species of shrubs and flowers—just the kind of a place one would expect “the father of systematic biology” to have lived and worked in.

#### SUMMARY

This report includes observations on the insect collections in 48 museums scattered throughout eleven countries in Europe, viz., England, France, Belgium, Holland, Denmark, Norway, Sweden, Austria, Czechoslovakia, Hungary, and Germany.

Of the 48 museum buildings included in this report, 18 were totally destroyed, four were partly destroyed, and 26 were left unharmed.

Of the 48 insect collections, six were totally destroyed, six were very badly damaged, and 36 were unharmed.

The German museums were, of course, the hardest hit, 16 of the 18 destroyed buildings being in Germany. Yet the Germans saved most of their collections by evacuating the collections and books to out of the way mountain retreats where they were housed in hotels, castles, or specially constructed buildings. This evacuation began as early as 1938 and included all of the great collections. 90 per cent of all the insects in the 48 museum collections reported on were saved; 95 per cent of the type specimens were saved.

Most of the European entomological publications continued throughout the war. The scientific publications of Germany poured from the press as late as March 1945, and a surprisingly large number of color plates were used to illustrate these journals. Good, enameled book paper was used freely in Germany throughout the war.

#### A REVIEW OF THE NORTH AMERICAN SPECIES OF PHILANTHUS, NORTH OF MEXICO (HYMENOPTERA: SPHECIDAE), by R. W. STRANDTMANN. 126 pages, 8 plates, 1946. The Ohio State University Graduate School Studies, Contributions in Zoology and Entomology, No. 7, The Ohio State University Press. Price

This attractively bound and well-printed little volume with its beautifully executed plates is a welcome addition to the literature of the wasps. Although it covers only thirty-one species, leaving three as undetermined, it is based on the examination of about 5500 specimens and so should stand as an authoritative work.

Dr. Strandtmann opens his study with a brief treatment of the biology of the genus, but the bulk of the book is devoted to its taxonomy. A description of the generic characters is followed by the synonymy of the genus, and this by a key to the species. Under each species are included the synonymy and bibliography, detailed descriptions of both sexes, the locations of types, the number of specimens examined and a tabulation of the geographic distribution. A brief discussion of salient characters and comparison with other species will be helpful in the use of the book.

Three of the plates figure adults of nine species, two figure faces, one antennae and a few other details and two are devoted to male genitalia. All are very well drawn and reproduced.

As an example of scientific publications from University Presses the volume is worthy of emulation.—A. W. L.

# REARING OF THE BLOWFLY, *PHORMIA REGINA* MEIGEN, ON A STERILE SYNTHETIC DIET

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It has been found desirable in this laboratory to attempt to rear the blowfly, *Phormia regina* Meigen, under conditions which avoid the stench and other undesirable features associated with the putrefying meat on which the larvae ordinarily are fed. In particular, a method was required which could be depended upon to produce a stock which would be more uniform physiologically and hence more suitable for comparing the effectiveness of candidate insecticides or for studying their mechanism of action.

At one time very elaborate methods were developed (White, 1937; Haub and Miller, 1932) for aseptic culture of the larvae of these flies which were used in the treatment of osteomyelitis. A few sterile culture methods have been described (Michelbacher, Hoskins, and Herms, 1932; Lennox, 1939; Fletcher and Haub, 1933) in which meat or other media in various forms have been used. Little has been reported concerning attempts to provide a synthetic diet under sterile conditions. Brown (1938) in his paper on nitrogen metabolism in *Lucilia sericata* (another species of blowfly) has reported using casein, yeast, agar, lanolin, and salt mixtures in the rearing of his experimental material.

In the method to be reported here, the principles set forth by Brown have been followed, with extensive modifications of technique for application to the rearing of *Phormia* for the purposes mentioned above.

## CULTURE METHOD

### Materials

(a) *Preparation of medium.* The medium includes the following constituents: powdered casein, brewers' yeast powder and powdered agar in proportions of 30 : 3 : 1, to which mixture is added lanolin and a modified Belar solution containing phosphate.

For convenience in preparation, the dry constituents have been combined in the following manner:

630 gm. casein, 63 gm. brewers' yeast and 21 gm. powdered agar were placed in a large fiber drum and shaken until thoroughly mixed, after which 30 gm. aliquots of the mixture were put into the half-pint milk bottles used as the culture vessels. To each bottle was then added about 3 gm. anhydrous or 4 gm. hydrous lanolin, followed by 60 cc. of a modified Belar solution. This solution was prepared by adding to one liter of water in the order given: 1.8 gm. NaCl, 0.04 gm. CaCl<sub>2</sub>, 0.04 gm. KCl, 0.04 gm. NaHCO<sub>3</sub>, 1.35 gm. NaH<sub>2</sub>PO<sub>4</sub> · H<sub>2</sub>O, and 1.55 gm. K<sub>2</sub>HPO<sub>4</sub>. Each salt was allowed to dissolve before the next was added. Finally, the volume was diluted to 2 liters.

After addition of the salt solution to the culture bottles the latter were plugged with non-absorbent cotton and autoclaved for 15 min. at 15-17 lbs. pressure.

*Procedure*

(a) *Obtaining and handling of the eggs.* A culture bottle prepared as outlined above should maintain the larvae hatching from about 500 eggs. The eggs are collected and transferred to the culture bottles in the following manner. Into the breeding cage of fertile adult flies is placed a chunk of ground horse meat (roughly cubical, 3 to 4 in. on a side), on which oviposition will occur. The meat is allowed to remain in the cage for only the 24-hour period between egg collections. At the end of this time the eggs are removed from the surface of the meat with forceps or needles and placed in 2% NaOH for 15 to 20 min. This separates the eggs from each other and from traces of the meat. The NaOH is then carefully decanted from the eggs and the latter are rinsed in 70% ethanol. The ethanol is poured off, additional 70% ethanol added, and allowed to remain for 15 minutes, at the end of which time the eggs are sufficiently sterile for introduction into the culture bottles.

If the eggs are drawn from the ethanol into a medicine dropper or pipette with long tapered delivery, they will settle out and pack near the opening. A few trials will locate quite accurately the level which represents approximately 500 eggs and this may be marked on the pipette for future reference. The eggs are then transferred to the culture bottles rapidly and preferably beneath a shield which provides a space free from draughts and outside contamination. The seeded bottles are closed at once with a sterile cotton plug.

(b) *Larval development.* At 25° C. and 70% relative humidity the eggs will hatch in less than 24 hours. For the first day or two the young larvae will wander, seemingly aimlessly, over the sides of the bottle and the surface of the medium. By the end of the second day, clustering takes place, usually at some point on the side of the bottle at the edge of the medium. Feeding continues until about the 8th day and it is only in the latter half of this period that rapid increase in size occurs. Frequently during the middle of larval development the culture may become too moist, with the result that the larvae tend to congregate just below the plug instead of continuing to feed. This migration may also occur at any time if too many larvae are present.

Migration away from the food because of excess moisture can usually be anticipated from the formation of a film of moisture on the inside surface of the bottle. At this time the plugs should be removed and autoclaved sawdust poured in until it is packed loosely to a level about 2 cm. below the top of the bottle. Covering the bottle with a disc of fine-meshed wire (40-80 mesh) is now advisable. The sawdust absorbs the excess moisture, driving the larvae back into the medium, and likewise functions as a sterile plug for the remainder of larval development. The sawdust should not be added earlier than just described, because the very young larvae may be attracted into it by food dissolved in the moisture which it absorbs. This food is soon used up and the young larvae seem incapable of re-establishing themselves on the medium below. The result is then a very non-uniform larval culture.

If it happens that more eggs are introduced originally than can be maintained as larvae on the amount of medium supplied, the medium will be consumed before the larvae are full grown and they will then tend to congregate at the top of the bottle. The culture may be saved by transferring these larvae to a fresh bottle. This is most easily accom-

plished by passing the old medium through a wire sieve so as to concentrate the mass of larvae in the smallest volume possible. After the larvae have been transferred, they should be covered with a fresh plug of autoclaved sawdust.

At about the 8th day the larvae will cease feeding and pass into a resting or prepupal stage. Prior to this they become very active and migrate through the entire contents of the bottle, mixing them thoroughly before coming to rest. If an appreciable amount of food remains unconsumed at this time, the result is a sticky wet mass of sawdust in which pupation is very irregular and in which many prepupae or mature larvae may remain unchanged for days. The percentage of emergence under these conditions is much less than when the sawdust remains dry. Ideally, therefore, the amount of medium supplied originally should be that which will just be used up at the time the prepupal migration occurs.

At maturity it is advisable to remove the larvae from the culture bottle and place them with about  $\frac{1}{4}$  inch of sawdust in a large shallow pan from which they can not crawl out. If the larvae are mature they will pass into the prepupal stage almost at once, and will pupate uniformly shortly thereafter.

(c) *Care and handling of pupae.* At 25° C. and 70% relative humidity the duration of the pupal stage is five to six days, emergence being on the fifteenth or sixteenth day after the eggs are laid. After sufficient pupae for breeding stock have been removed for emergence in the breeding cages, the remainder may be set up for future experimental use. The following method has been found convenient for this purpose:

One hundred or more pupae are placed in a small cup which has been mounted securely on one end of a piece of plywood, 1.5 x 6 in. A similar cup on the other end of the support contains sugar and water. A piece of paper toweling is laid on the water surface. The cups may be of any convenient waterproof material but should be of not less than 20 cc. capacity and of such shape that the whole assembly will fit easily into a 1-qt. Mason jar laid on its side. A No. 7 short taper cork is fastened to the underside of one end of the plywood support; the other end rests in the neck of the jar. The mouth of the jar is covered with a wire screen disc held in place by the jacket of an ordinary two-piece Mason jar lid. The screen is pierced by a small hole, fitted with a cork, through which a pipette may be inserted to replenish the water in the cup containing the sugar solution. This cup should therefore be toward the mouth of the jar, and the pupae toward the rear. When the jars are made up, they are placed in a rack to avoid rolling of the jar and spilling of the contents of the cups.

The use of this assembly minimizes the amount of handling otherwise needed in gathering flies for experimental purposes. It also has the advantage that all flies may be used, so that it reduces the number which needs to be cultured. Collection of flies from a large cage is difficult unless the cage contains several times the number of flies needed.

(d) *The adult.* On emergence, the young adult flies must be supplied with sugar and water. If they are to be used for breeding, fresh-ground horse meat should also be furnished daily. Cages of any convenient size and construction may be used for the maintenance of breeding stock, and repopulated by the addition of fresh pupae as

required. On a meat diet oviposition should start by the end of the first week after emergence. It has been found that breeding cultures are maintained in better condition when a halved orange is available in each cage. Best results are obtained when the flies are not overcrowded. About 300 flies per cubic foot of cage space is a satisfactory number. An indication of overcrowding is an almost continuous buzzing noise in the cage. A cage containing 600 mature adults will produce sufficient eggs to seed 2 bottles daily, without requiring undue waste of time in removing the eggs from the meat.

#### DISCUSSION

The necessity for a number of the precautions which have been given in some detail above lies in the variability of the percentage hatch of the eggs obtained from such a culture. The causes for this variation are not known, but the percentage of eggs hatching may range from about 50% to nearly 100%. Some flexibility in the handling of the larvae is therefore required. For example, if the total number of eggs placed in a culture bottle were to emerge, an early transfer of the culture to fresh medium would be necessary for the completion of development. On the other hand, a hatch as low as 50% would necessitate the removal of the mature larvae from the bottle at the time migration commences in order to ensure uniform pupation.

When these factors are recognized and dealt with suitably, a remarkably uniform and healthy culture of flies is obtained. Adults from such a culture are running some 20% to 25% higher in weight than those formerly obtained from contaminated meat. Greater uniformity in the response to treatment with insecticides has also been noted, so that the number of tests required for significant comparisons has been considerably reduced. The reduction in disagreeable odor, provided the cultures are kept free of bacterial contamination, is also a considerable advantage, since it removes the necessity of keeping the culture in a separate room with special ventilation.

#### CONCLUSIONS

A method has been developed for rearing the blowfly, *Phormia regina* Meigen, on a sterile synthetic medium.

The advantages of this method over the use of the natural medium, putrid meat, are ease of handling, relative freedom from disagreeable odor, and the production of a more uniform and healthy strain of flies for experimental purposes.

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## DESCRIPTION OF A NEW MYMARID WHICH PARASITIZES THE EGGS OF THE SARATOGA SPITTLEBUG<sup>1</sup>

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An interesting new mymarid and an aphelinid to be described later were discovered during the late summer of 1946 at Lakewood, Wisconsin, while a study was being made of the Saratoga spittlebug, *Aphrophora saratogensis* (Fitch); both appear to be undescribed.

In the following description of the mymarid F-I to F-VIII refer to the segments of the antennal funicle, while *M* (marginal), *Sm* (submarginal) and *Pm* (postmarginal) refer to the wing veins.

### *Ooctonus aphrophorae*, n. sp.

*Female*.—Entire length in natural position, including ovipositor, about 1.4 mm.; head and thorax, 0.67 mm.; petiole, 0.19 mm.; remainder of abdomen, 0.95 mm.; ovipositor sheath, 0.21 mm. Head when viewed from above sub-rectangular, one and two-thirds times wider than long, polished, microscopically reticulate-punctate on the vertex and front, the occiput, genal, and postgenal areas mostly with weak irregular reticulate sculpture; mandibles tridentate; eyes with inconspicuous, sparse, short cilia; scape, including radicle, as long as or longer than combined lengths of pedicel, F-I and F-II, compressed and slightly bent, narrow at the base, wider through the middle and attenuated at the apex; pedicel from lateral aspect twice as long as thick, equal to F-I plus about one-third F-II; F-I to F-V almost equal in length, each a little more than twice as long as thick, each increasing but slightly in thickness; F-VI shorter than either F-V or F-VII and less than twice as long as thick; F-VIII but slightly shorter than F-VII, neither twice as long as thick; club solid with distinct linear placoid sensilla, approximately three times as long as thick and slightly longer and thicker than the last three funicular segments combined. Thorax narrower than head, about one and two-thirds times longer than wide, shining; mesoscutum finely reticulate; axillae broadly united and with sculpture similar to that of mesoscutum; mesoscutellum with distinctly coarser more irregular reticulations; parapsidal grooves not deeply impressed but weak or poorly defined; metanotum irregularly sculptured with few minute carinae extending forward from posterior margin and a stronger complete lateral longitudinal arcuate carina; sides of thorax mostly smooth and polished; propodeum feebly irregularly sculptured and with prominent carinae, the branches of the median carina forming a more-or-less vertical diamond, truncate below, the lateral angle connected by a short transverse carina to a lateral carina. Petiole smooth, a little more than three times as long as its greatest thickness, strongly bent

<sup>1</sup>The writer is indebted to A. B. Gahan, of the Bureau of Entomology and Plant Quarantine, for checking the manuscript.

and constricted at the base, so that almost its entire length lies between the coxae when in natural position; abdomen smooth and polished, compressed and somewhat blade-shaped anteriorly, depressed and sharply pointed posteriorly, attached on its dorsal margin to petiole with approximately one-sixth the total length projecting forward, so that at least one-half or more of the abdomen lies beneath the head and thorax when in natural position. Coxae moderately large, the legs somewhat long and slender; first segment of hind tarsus about as long as the second and third combined. Forewing about two and seven-tenths times as long as wide, subtruncate along the outer margin, evenly and densely ciliate except bare at extreme base, the longest marginal cilia approximately as long as one-seventh the greatest wing width; *Sm* thin, twice as long as *M*; *Pm* discernable in a furrow behind anterior wing margin for a distance about equal to one-half the length of *M*, gradually narrowed to a fine point; hind wing about fourteen times as long as broad, rather densely ciliate, the longest marginal cilia about one and one-half times the greatest wing width. Antenna and legs moderately densely pubescent, the head and remainder of body sparsely so. Color: Uniformly shining black except pedicel beneath and all tarsi are yellowish. Wings subhyaline, the veins brown.

*Male*.—Length about 1.29 mm.; head and thorax, 0.74 mm.; petiole, 0.18 mm.; remainder of abdomen, 0.45 mm. Head similar in shape and sculpture to that of female; eyes with short, sparse, inconspicuous cilia; antenna longer than the body and a little longer than the forewing, the segments beyond the pedicel with conspicuous parallel linear placoid sensilla; scape compressed, bent, narrowest at base, widest through the middle and tapering distally, longer than any other segment but subequal to pedicel and F-I combined; flagellum mostly uniform in width, the distal segments tapering gradually; pedicel approximately three-fifths as thick as long, and one-half to two-thirds as long as F-I; F-I usually distinctly shorter than F-II and subequal to F-III; F-II to F-VIII all equal or nearly so; last three segments of flagellum only slightly shorter than the preceding segments and nearly equal to each other. Thorax similar in shape and sculpture to that of the female except sculpture on posterior two-thirds of mesoscutellum similar to that of mesoscutum, that on the anterior one-third finer; metanotum variously sculptured with minute carinae posteriorly and a stronger arcuate carina laterally; propodeum with a carinate pattern like that of the female but often not otherwise distinctly or strongly sculptured. Petiole subcylindrical, smooth, narrower anteriorly, about four times as long as its greatest thickness; abdomen from above diamond-shaped, from lateral aspect somewhat triangular (often much depressed), smooth and polished; genitalia usually exposed. Forewing two and one-half times as long as the greatest wing width, longer and wider than that of the female; *Pm* visible for a distance about equal to the length of *M*, and located in a more distinct furrow; hindwing about sixteen times longer than the greatest wing width, the longest marginal cilia longer than twice the greatest width; ciliation of wings otherwise similar to that of female. First segment of hind tarsus slightly shorter than the following two segments combined. Pubescence similar to that of female except the antenna with shorter and sparser hairs. Color: Like that of female.

*Variations.*—(Female). The scape sometimes appears longer than usual, and may be subcylindrical, its thickness being less than is typical. The last funicle segment of some females does not appear conspicuously shorter than the preceding. The metanotum, and the propodeum except for the prominent carination, may be only faintly sculptured or smooth. The petiole, which varies slightly in length, may be as long as 0.21 mm. Perhaps the most obvious structural variation has to do with the length of the ovipositor sheaths which range from 0.126 to 0.266 mm., the average being near 0.14 mm. There is little variation in size of female specimens.

The darkest females are almost entirely black except the extreme distal ends of the tibiae and the basal segments of the tarsi, which are yellowish brown.

(Male). The segments of the antenna are somewhat variable. Sometimes F-II and F-III appear equal, and F-I may be equal to F-III and very nearly as long as F-II. The metanotum may be irregularly reticulate rather than carinate, or weakly sculptured to almost smooth with a prominent lateral carina. The propodeum may be smooth between the carinae and the diamond formed by the branches of the median carina may not be truncate below. The petiole ranges in length from 0.154 mm. to 0.182 mm. Often the abdomen retains its natural shape, in which case from the lateral aspect it appears triangular in outline, the sides measuring approximately two-thirds the width of the base, with the vertical apex above the center of the base.

Lighter specimens may have the front femur, the middle and hind tibiae, the scape mostly, and the pedicel beneath, light brown, especially if examined under strong white light. The darker specimens may have the tibiae and the tarsi mostly brown. Infuscation on the tarsi ranges from being virtually absent on light males to involving all the segments. Males range in length from about 1.24 mm. to 1.33 mm.

Described from the holotype (female) and allotype (male) and a series of 53 male and 84 female paratypes, all reared from eggs of *Aphrophora saratogensis* (Fitch) collected at Lakewood, Wisconsin, between September 18 and 26, 1946, by the writer; all deposited in the collection of the United States National Museum.

Also identified as this species is a series of 17 males and 26 females reared from the eggs of the above host collected by the writer in September 1946 at Lakewood, Wisconsin, and a series of 18 males and 30 females taken by sweeping jack pines during that period in the same locality. All except a reared series of three females and three males in the collection at the Milwaukee laboratory of the Division of Forest Insect Investigations are deposited with the types.

*Type:* Cat. No. 58267 U. S. N. M.

*Type Locality:* Lakewood, Wisconsin.

#### MISCELLANEOUS OBSERVATIONS

On August 23, 1946, the eggs of *Aphrophora saratogensis* were first discovered to be subject to attack by parasites, when old egg shells, probably those deposited the previous year, were found to contain parasite exit holes. Early in September an old egg was located which contained a live parasite nearly ready to emerge. The specimen was



preserved in fluid and when later dissected was found to be a male in a condition too poor for further identification other than to place it in the family Mymaridae. Without question this appeared to have been a 1945 specimen. Subsequently, fragments of a male of apparently the same species were discovered, but not until September 7 was a living specimen obtained. A male then emerged from among old eggs, of which some were parasitized, in dead red maple twigs collected a few days before. For a time after this several males were swept from jack pines, and also a few females suspected of being the same species. The first reared females which emerged September 12 from old eggs, were identical with those collected in the field. Thereafter both sexes were reared in large numbers between September 22 and October 12 from host eggs collected September 18 to 26. These host eggs were deposited during the 1946 season. All adult parasites reared prior to September 22 had issued from host eggs that had been deposited in 1945.

The adults are very active in confinement and have been observed mating in vials. While they are at rest the flagellum is held in a porrect position, but while moving the antennae are constantly kept vibrating up and down in rapid fashion.

Though fresh host eggs were supplied on several occasions, oviposition in these eggs was never observed. However, study of host material collected in the field showed that parasitized eggs become turgid, somewhat distorted in shape, and a little larger than unparasitized eggs. A characteristic pink spot that is present in the unparasitized host egg becomes translocated and soon disappears. The parasitized egg at that time is dull whitish pink or lavender, and gradually becomes greyish blue to bluish black, and finally black. The parasite has been observed to exit from either end of the host egg.

Limited samples of host eggs collected during the third week in September showed that parasitization ranged from 8.5 to 9.3 per cent. It is believed that examination of samples collected later in September and during October would show higher percentages, and that the parasite may be of considerable economic importance as an aid in the control of its host.

**THE COLEOPTERISTS' BULLETIN.**—This new publication made its appearance on April 1, 1947. The first issue contains a preliminary list of the coleopterists of North America, indicating their interests, projects under way and exchanges offered and desired. Short articles by Henry Dietrich and Barry D. Valentine of Cornell University on the habits of certain beetles are also included.

Plans for the bulletin include expansion among coleopterists of North America and foreign countries and general aid for their practical work such as collecting notes, reviews of publications, and the location of collections. It will appear ten times per year and is edited by Ross H. Arnett, Jr.

The Bulletin is for the professional coleopterist and for serious amateurs who are interested in sound scientific work. It is mimeographed.

Those who are interested are asked to send their names and addresses, with a statement of groups being studied, material desired, and other practical information of the kind mentioned above. The subscription price is \$1.00 per year. Communications should be addressed to the Coleopterists' Bulletin, The Sherwood Press, Box 84, Dryden, New York.—A. W. L.

# BIONOMICS OF MONODONTOMERUS MANDIBULARIS GAHAN, WITH NOTES ON OTHER CHAL- CIDS OF THE SAME GENUS

PHIL RAU,  
Kirkwood, Mo.

This Chalcid, *M. mandibularis*, has only recently been described as new by Mr. A. B. Gahan (3),<sup>1</sup> but previous to the publication of his paper the insect has been erroneously called *M. montivagus*. In my paper (6) it is called *M. montivagus*, and in another publication (7) details of its life history are recorded as *Monodontomerus* sp. The material used for both of these papers has been re-examined by Mr. Gahan, who finds them to be *M. mandibularis*. There is some reason for this confusion, for Mr. Gahan says that this species is difficult to distinguish from *M. montivagus*; and in a personal letter he says that *M. montivagus* is a good species, but apparently occurs only in the far West.

Students of the Chalcid material from the far West, Hicks (2), Linsley and McSwain (4) and Mickel (5), working with *M. montivagus*, have compared the biology of the western *montivagus* with those erroneously named in my papers. Now, since my Chalcids prove to be another species, any comparisons can be only analagous rather than specific.

Little indeed is known of the life history of *M. mandibularis* or of its near kin, *M. montivagus*, and what little has been noted on the life of the Chalcids has been incidental to work on their hosts which are usually, but not always, *Anthophora* bees. It was in its relation to *Anihophora abrupta* that I first became acquainted with *M. mandibularis*.

At that time I was impressed by the great disproportion of the sexes; the females greatly outnumbering the males. In recent years I have often observed both *Anthophora* and *Monodontomerus* in the little artificial clay bank in my yard, where the following limited observations were made.

## PROPORTION OF THE SEXES

In 1917 (6), I found that of the 218 *M. mandibularis* which emerged from ten *Anihophora abrupta* cells, 31 were males and 187 females. This great disproportion was later confirmed by Dr. C. E. Mickel (5), who found the near kin, *M. montivagus* parasitic on *Anthophora occidenitalis*; in his experience 94 per cent of the specimens bred from 21 bee cells were females.

On the contrary, Hicks (2) in his examination of *M. montivagus* with a parasitic bee, *Pseudomelecta miranda* as host, found the reverse to be true, for out of 14 *M. montivagus* from one cell, 11 were males.

In an attempt to settle the question, I removed a large lump of clay from the bank in my yard and amused myself during the winter evenings of 1945-46 by carefully removing the *A. abrupta* cells from it and placing each in a separate test-tube, preparatory to examining them

<sup>1</sup>Figures in parenthesis refer to titles in the bibliography.

later when the insects all would have emerged. A total of 159 cells were thus kept, which later produced the following insects:

<i>Anthophora abrupta</i> .....	121
Cells with <i>M. mandibularis</i> .....	16
Cells with pollen but no egg, some fungus-covered...	18
Cells with small dead bee larvae.....	4
	<hr/> 159

The contents of the 16 cells containing *M. mandibularis*<sup>2</sup> are tabulated here:

Cell No.	Date of 1946 Emergence	No. of Males	No. of Females	Total
1	April 25.....	1	11	12
2	" ".....	1	32	33
3	" ".....	2	18	20
4	" ".....	1	7	8
5	April 31.....	1	17	18
6	May 1.....	0	7	7
7	" ".....	4	19	23
8	May 10.....	1	19	20
9	" ".....	1	11	12
10	" ".....	1	15	16
11	May 14.....	1	24	25
12	" ".....	1	16	17
13	" ".....	3	21	24
14	" ".....	2	19	21
15	" ".....	3	22	25
16	" ".....	4	23	27
	Total.....	27	281	308 <sup>3</sup>

Here again the preponderance of females is conspicuous. Of the 308 Chalcids which emerged from the 16 cells, 27 were males and 281 females, or 91 per cent, which is comparable with the results which Mickel obtained for *M. montivagus*. Nine of my bee cells had but one male each of the parasite, and one cell had no males at all. The maximum number of males was four, appearing in only two cases.

All of the occupants of a cell emerged during one day; this indicates (but does not prove) that all in a cell become adult simultaneously, for occasionally when I broke open a cell I found the entire population fully winged, apparently awaiting an opportunity to leave. They all leave by one tiny hole which one of them makes in the mud wall, and apparently the crowd awaits the initiative of a pioneer to open the way to liberty.

At first it seemed possible that the predominance of females might be due to the weaker males dying in the cells. With this in mind, I opened each cell for examination after the Chalcids had emerged, but found no dead males except the four listed in the foot-note.<sup>3</sup>

<sup>2</sup>The Chalcids from these cells were identified by Mr. A. B. Gahan.

<sup>3</sup>The total includes 2 females and 1 male which were found dead in Cell No. 7, 2 males found dead in cell 15, and 1 male found dead in cell 16.

## ROLE OF THE MALE

Of course we do not know if parthogenesis occurs, or if the race is propagated by polyembryony, but regardless of which it may be, I feel reasonably certain that here in Missouri Valley at least, the males have little to do with the production of future generations. They are seldom seen flying in the sunshine in front of the clay bank, as do the robust females, and the few which were present were very frail and weak. In my cages, they lived only a few days, and were never seen to attempt to mate, but the females lived there for up to 22 days. It seems improbable that mating occurs in the dark cell before they emerge, especially since the females so greatly outnumber the males, as in cell 2, where there was only one male to 32 females, or even in cell 6, where there were no males at all.

What we have found in Missouri for *M. mandibularis* differs from that of the western *M. montivagus*, for Linsley and McSwain (4) found that mating does occur, one male often fertilizing several females, and also that copulation is preceded by a preliminary courtship, which they have interestingly described.

## THE METHOD OF OVIPOSITION

No one yet knows with certainty how the young Chalcid reaches the host, whether the eggs are deposited in the open cells, or whether they are dropped near the tunnels and later the ensuing larvae penetrate the hard walls of the brood-cells to reach their hosts.

The life of *M. mandibularis* runs parallel with that of its host. For example, in 1946, the parasites emerged between April 25 and May 14, and the *Anthophora* bees from April 29 to May 13, both in the laboratory and outside in the clay bank.

During the early days of their lives, both bees and parasites are active at the clay bank, the bees mating and making tunnels, and hordes of Chalcids flying about almost constantly before the tunnels. Later, the latter often pause to rest on the lumps of clay, and enter the bees' burrows and also spend the night there. I am inclined to think that it is at these times that the eggs are surreptitiously laid there. The idea that the eggs may be scattered promiscuously in the crevices of the bank is, I think, scarcely tenable, since the *Anthophora* make within their tunnels distinct cells of hard clay, lined with a varnish-like coating, both of which would be extremely difficult for larvae to penetrate. Moreover, I carefully examined all of the parasitized cells for marks of such penetration, but found none.

## THE NUMBER OF PARASITES WHICH MAY BE SUPPORTED BY ONE HOST

It is interesting to note the number of Chalcids which may be supported by one host *Anthophora* bee. In this case, the 16 bees nourished to maturity 308 *M. mandibularis*, or an average of 19.2 per host. This count agrees well with Mickel's findings for *M. montivagus* which were detrimental to *A. occidentalis*, for his study of 21 cells showed an average of 19.7 Chalcids.

If polyembryony be a factor in their multiplying, then we would expect a direct relation between the number of parasites and the size of the host. There is some indication that such a relation may exist, as

for example, when *Osmia cordata* is host (a bee about half the size of *A. abrupta*), I found (9) the number of *M. montivagus* per cell in three instances to vary from 4 to 6. Linsley and McSwain (4) state that when the host is a mutillid wasp, *Photopsis*, only half as many *M. montivagus* emerge as from a normal cell of *Anthophora*. *Photopsis* is apparently much smaller than *A. linsleyi*, since it is a secondary parasite upon it.

It is clear that under this heading are involved at least a half-dozen important biological problems which are worthy of further study.

#### HOSTS OF *M. MANDIBULARIS*

I have found enormous numbers of these Chalcids at the clay bank at Wickes, Missouri, year after year (7), where more than a dozen different kinds of their possible hosts nested, but I never made a complete list of them. By way of apology, I might say that a complete survey in quest of this knowledge would have meant too great a destruction of the clay bank, which was too valuable for other studies. However, the white-banded bees, *Entechnia taurea*, were just as abundant there as were the *A. abrupta*, and although they appeared a little later, the former could easily have been parasitized. In fact, Gahan (3) reports an actual case of such parasitism.

In the light of Mr. Gahan's recent study, it is quite likely that the species involved in the record of parasitism in the bee *Osmia cordata* is *M. mandibularis*. In the record (14) the name of *M. montivagus* is undoubtedly incorrect, since others at about that time that were so named proved to be *M. mandibularis*. It is therefore quite justifiable I think, to add *Osmia cordata* to the list of hosts of *M. mandibularis*.

#### HOSTS OF *M. MONTIVAGUS*

I have bred *M. montivagus* also from the cells of the bee *Osmia cordata* (9), and in Mexico found them (11) in the cells of the resin-bee, *Megachile peruviana*, and Mickel (5) finds them parasitic on *A. occidentalis*. Hicks (2) has bred them from *A. neomexicana* as well as from *Pseudomelecta miranda* which is itself a parasite on *A. neomexicana*. Linsley and McSwain (4) find that they infest *A. linsleyi*, and are also secondary parasites on the Mutillid wasp *Photopsis auraria* Blake. In addition to this one and only reference to a wasp as host, I have bred them from the cells of wasps *Stenodynerus mysticus* (13), and from the mud-wasp, *Trypoxylon pallid tarsus* (12). The hosts and parasites of the last two were brought from Mexico.

To summarize then, we might say that so far, *M. mandibularis* is known only as a primary parasite on *Entechnia*, *Osmia* and *Anthophora* bees, but that *M. montivagus* is both a primary and a secondary parasite, and its hosts may be wasps as well as bees.

#### HOSTS OF *M. OBSCURUS* WESTWOOD

This Chalcid, determined by Mr. A. B. Gahan, was bred from a cocoon of *Osmia lignaria* in 1939. This cocoon was in an old mud-dauber's nest taken at Wesco, Missouri. Also in 1945 several adults of *M. obscurus* were taken at the clay bank in my yard, evidently having been brought in with *Osmia* cocoons in mud nests. The parasite on *Osmia cordata* referred to as *Monodontomerus* sp. (9) proved also to be

*M. obscurus* (3). Dr. Gahan (3), after discussing the taxonomic position of this insect, says:

"This species apparently has not been previously recognized from America. In Europe it is variously recorded from hymenopterous, dipterous, and lepidopterous hosts. Among the hymenopterous hosts [in Europe] there are at least 3 species of the genus *Osmia*."

This indicates that this European parasite is becoming naturalized in America and has penetrated the portals of at least two species of Missouri *Osmia* bees.

#### HOSTS OF *M. MEXICANUS* GAHAN

The Chalcid referred to as *M. n. sp.*, parasitic on the mud wasp, *Trypoxylon mexicanum*, (10) and the aphid-wasp, *Passaloecus pusillus* (11) as well as on the resin-bee, *Megachile peruviana* (11) have been named by Mr. Gahan, *M. mexicanum* (3). These Mexican Chalcids, we may note, are parasitic on both bees and wasps.

#### THE NUMBER OF GENERATIONS EACH YEAR

In Missouri, *M. mandibularis* hibernate as immature insects within the heavy masonry walls of *A. abrupta*, and at the end of April or early May emerge as adults in great numbers, where they frolic and dance before the cells of their hosts, who appear at about the same time. The life of the parasite parallels that of the host, and both disappear in mid-July, when the dead bodies of both may be seen strewn about the clay bank.

I suspected that there was but one generation each year, but was surprised to find that during the years 1917, 1918 and 1920 (7), when I was able to spend much time at the clay bank, that a second crop appeared early in September which stayed on until cold weather. Seeing this second crop after a lapse of four or five weeks led me to conclude that there are two generations a year. In support of this idea, I later found (8) in a cell removed from the bank as late as June 28, twenty *M. mandibularis* in the pupal stage, and also from several cells brought indoors on June 24, 1920, I bred adults on September 2. In addition to this, the near relative, *M. montivagus* which emerged from the cells of *Trypoxylon palliditarsus* did so in early August (12), and those of *M. montivagus* which emerged from the cells of *Stenodynerus mysticus* (13) did so between August 28 and September 5.

It seems there is some justification for interpreting this discontinuous emergence as representing two or more generations a year. On the other hand, it is more likely that the Chalcids gave this appearance because various ones parasitized various hosts as the hosts appeared in succession in the clay bank, and since the development of the young parasite depends upon the growth of its food supply, it must perforce parallel the development of its host and emerge at the same time. It is interesting to note in this connection that in the clay bank at Wickes (7), where a dozen species of hymenoptera lived at various times during the summer, I found the discontinuous appearance of the parasites, but in the small clay bank at home, where they had little to choose as hosts but *A. abrupta*, there was only one generation a year which came and went simultaneously with their hosts.

If there is but one generation per year, it would indicate that the eggs are laid in the host cells when the tunnels are wide open, and that different broods appear at different times according to the appearance of their various hosts.

#### CONCLUDING REMARKS

Dr. Mickel, in 1928, said, "There is practically nothing known about the life history of *M. montivagus*. The number of generations per year, how it gains entrance to the cells of the bees, how and where it lays its eggs, how the larva develops, the possibility of the insect being polyembryonic and parthenogenetic, whether it is restricted to *Anthophora* bees in its parasitic relations, or whether it may be both a primary parasite and a secondary parasite, and whether one species of *Monodontomerus* parasitizes several species of *Anthophora*, or whether each species of the latter has its own species of *Monodontomerus*, all are questions which would bear investigation."

This paper does little, I fear, to satisfy the challenge of Mickel's inventory. The great bulk of the bionomics of this parasite remains yet to be worked out. However, since Mickel wrote, a few of these points have been cleared up by Linsley and McSwain, and by myself. To summarize these points, we now know that *M. montivagus* is both a primary and a secondary parasite, but as far as we know, *M. mandibularis* is only a primary parasite. In both species, the females are greatly in excess of the males in numbers. *M. mandibularis* is parasitic on at least three species of bees, but *M. montivagus* parasitizes both bees and wasps. *M. mexicanus* also parasitizes both bees and wasps.

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## STUDIES ON ARTHROPOD CUTICLE

### I. THE DISTRIBUTION OF CHITIN IN LEPIDOPTEROUS SCALES, AND ITS BEARING ON THE INTERPRETATION OF ARTHROPOD CUTICLE.<sup>1, 2</sup>

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A few years ago Anderson & Richards (1942) reported that the brilliant iridescent blue scales of the tropical butterfly *Morpho cypris* contain no chitin. The report, incidental to a study of scale architecture, was based on the usual test of solubility in hot concentrated alkali but also included the fact that electron micrographs of less drastically treated scales showed intermediate stages of dissolution. Being desirous of knowing whether or not this is generally true of insect scales, the present author performed tests on a series of specimens representing 109 species of 103 genera and 45 families of Lepidoptera in addition to scales of a mosquito and silverfish.<sup>3</sup> Results were highly variable from one species to another and not always easy to duplicate. We were forced to conclude that lepidopterous scales may contain either large amounts or small amounts or no demonstrable chitin.

#### METHODS

Several techniques were used. Routinely, for the majority of the data presented in the table, the Van Wisselingh (1898) sealed tube technique was used. Scales scraped from the wing or more commonly pieces of wing with scales attached were sealed in Pyrex glass tubes in a concentrated solution of alkali containing 400 grams of reagent grade pellets assaying 85% potassium hydroxide to 250 milliliters of distilled water. The tubes were heated in a glycerine bath to approximately 160° C. for 15 minutes. After cooling, the tubes were broken open, the contents poured into a watch glass and examined microscopically. Selected scales, if any could be located, or pieces of wing membrane that might bear scales were then washed either in water or alcohol and tested for chitosan by the iodine-sulfuric acid method (see Campbell, 1929).

In numerous cases of darkly pigmented scales the alkali treatment did not remove enough color to permit seeing the chitosan color test. Such dark scales were bleached in potassium permanganate followed by sodium bisulfite before applying the iodine test.

In all cases tests were replicated at least once. All cases giving negative or variable results were tested repeatedly.

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<sup>2</sup>The work described in this paper was done under a contract between the Medical Division of the Chemical Warfare Service and the University of Minnesota.

<sup>3</sup>Acknowledgement is made of the assistance of Mr. Ben Onodera in making some of these routine tests.



In addition to alkali treatments we used several strong oxidizing agents to purify the chitin by oxidation of the protein and other components. Solutions used were 30% hydrogen peroxide, 1% potassium permanganate, and diaphanol (saturated solution of chlorine dioxide in 50% acetic acid). Treatment with these oxidizing agents was in sealed glass ampoules in the dark. Since Fraenkel & Rudall (1940) have shown that even diaphanol, the strongest of these, requires about 9 weeks to purify chitin, we used them at room temperatures for periods up to 12 weeks.

The value and validity of these various tests will be discussed in a later section.

#### THE OCCURRENCE OF CHITIN IN SCALES

A summary of the data obtained is presented in tabular form with the species arranged in systematic order. The listing follows that of the most recent checklist of North American Lepidoptera with the relatively few exotic species inserted in appropriate places. Identifications were made partly by the author and partly by selection of specimens from series identified by other specialists.

There is already a voluminous literature on lepidopterous scales, especially as relates to the comparative morphology and developmental genetics of pattern formation. The present point is not covered in this literature although the assumption is commonly made that scales are "chitinous" and even that they may show different degrees of "chitinization." For a recent review of the field see Caspari (1941).

Examination of the table shows that in slightly more than half of the species studied seemingly all of the scales were resistant to the hot alkali and subsequently gave a positive chitosan color test. In other words, such scales give a strong positive qualitative test showing the presence of a considerable amount of the chemical chitin. In only a very few cases were all of the wing scales regularly destroyed by alkali; these would be said to contain no chitin or, to be more exact, to be negative for chitin by the classical van Wisselingh test. In a considerable number of species some one or more scale types was regularly destroyed by alkali but other scale types on the same wing were resistant to alkali and gave a positive chitosan color test. In a number of cases a given scale type was sometimes destroyed by the alkali but other times not destroyed; such scales when not destroyed give a positive chitosan color test. These will be discussed in the next section.

Study of the tabular data shows that it is difficult to draw any general conclusions correlating the presence of chitin with any particular type of scale. Obviously there is no significant phylogenetic correlation. One can point out that dark scales containing a large amount of melanins always gave a positive test for chitosan (after bleaching). Iridescent scales are usually destroyed but at least *Chlorippe seraphina* is an exception. There may well be other exceptions since in cases such as *Papilio philenor* where an iridescence overlies a black ground we could not be sure what happened. We did frequently note that scales of the hind wing are more likely to be destroyed than those of the fore wing, that scales from the center of the wing are more likely to be destroyed than those around the margin, and that intensely pigmented scales

usually give a positive reaction. As the work proceeded we found that we could not predict what was going to happen with the next species except that black scales were always found to be positive.

The most intensive work was done with the two species of *Morpho*. The series of electron micrographs showing progressive dissolution of the scales of *Morpho cypris* with increasing alkali treatment seems to the author unquestionable evidence that these scales are indeed readily destroyed by alkali treatment (Anderson & Richards, 1942). The iridescent scales of *M. peleides* are also destroyed by lower concentrations and temperatures (e. g. 8 per cent NaOH at 85° C. for 15 hours). These scales do not, however, lose their iridescence on prolonged digestion in a 10 per cent pepsin solution even after preliminary refluxing with boiling chloroform. The iridescent scales of *M. peleides* are destroyed by even relatively short treatments with the oxidizing agents which are not known to affect chitin. The non-iridescent brown scales of these species of *Morpho* are not destroyed by either hot concentrated alkali or by oxidizing agents and give a positive chitosan color test. Accordingly whether one relies on the classical van Wisselingh-Kühnelt-Campbell hot alkali methods or the Schulze-Kunike-Koch diaphanol method, one has to conclude that the iridescent scales of these species lack chitin while the non-iridescent scales contain chitin.

A few other species were also tested with diaphanol. After 5½ weeks treatment all the scales except the marginal fringe were gone from the wing of *Euchloe olympia*, the iridescent scales but not the other scales were destroyed on the wing of *Ailides halesus*, but there was no dissolution of scales from the wings of *Phryganidia californica* or *Alypia octomaculata*. There is, then, fairly close agreement between dissolution by hot alkali and by prolonged treatment with diaphanol but the alkali treatment is inclined to be more destructive.

Incidentally, using *Galleria mellonella* it was shown that these scales first develop in the pupa into characteristic types without any chitin being detectable (readily destroyed by alkali) but then about the time the pattern is becoming visible on the unpigmented wing chitin begins to be detectable. Scales from the adult wing give a strong chitosan test. The parallel to the development of the cuticle of the body wall is obvious.<sup>4</sup>

<sup>4</sup>Incidentally, the author has shown the same sequence for development of the larger tracheae of *Blatta orientalis* L.

TABLE I

DATA ON ALKALI SOLUBILITY AND CHITOSAN COLOR TESTS OF THE SCALES OF  
VARIOUS SPECIES ARRANGED SYSTEMATICALLY  
(F=fore wing; H=hind wing)

FAMILY	GENUS AND SPECIES	WING	DISSOLVED BY HOT ALKALI	POSITIVE CHITOSAN TEST
Papilionidae....	<i>Papilio philenor</i> L.....	F & H	Yellow.....	Dark scales
	<i>Papilio glaucus</i> L.....	F	Some yellow.....	Black & yellow
	<i>Papilio marcellus</i> Cram.....	F	.....	All
	<i>Parnassius smintheus</i> D. & H.....	F & H	.....	All
	<i>Troides rhodamanus</i> Lucas.....	H	.....	All

TABLE I—Continued

FAMILY	GENUS AND SPECIES	WING	DISSOLVED BY HOT ALKALI	POSITIVE CHITOSAN TEST
Pieridae.....	<i>Euchloe olympia</i> rosa Edw.....	F & H	All light.....	Dark
	<i>Colias eurytheme</i> Bdv.....	F	Yellow usually.....	Black (some- times yellow)
Danaiidae.....	<i>Appias nero domitia</i> Feld.....	F	.....	All
	<i>Pieris rapae</i> L.....	F & H	White.....	Dark
Satyridae.....	<i>Danaus plexippus</i> L.....	F	.....	All
	<i>Enodia portlandia</i> Fabr.....	F & H	Commonly.....	When not dis'lv'd
Nymphalidae...	<i>Megisto eurytus</i> Fabr.....	F & H	.....	All
	<i>Coenonympha ochracea</i> Edw.....	F & H	.....	All
Nymphalidae...	<i>Minois alope nephele</i> Kirby.....	F	.....	All
	<i>Heliconius paterivramus</i> Dbldy.....	F & H	Orange sometimes.....	Black & yellow
Nymphalidae...	<i>Argynnis eurynome</i> Edw.....	F	.....	All
	<i>Polygonia interrogationis</i> Fabr.....	F	.....	All
Morphidae.....	<i>Vanessa io</i> L.....	F & H	.....	All ?
	<i>Hypolimnas bolina otaheitis</i> Feld.....	F & H	Some, variable.....	Most
Morphidae.....	<i>Chlorippe seraphina</i> Hbn.....	F & H	.....	All ?
	<i>Morpho cypris</i> Westw.....	F & H	Iridescent.....	Brown & Black
Libytheidae.....	<i>Morpho peleides limpida</i> Butl.....	F & H	Iridescent.....	Brown
	<i>Libythea bachmani</i> Kirby.....	F	.....	Brown
Libytheidae.....	<i>Libythea geoffreyi philippina</i> Staud.....	F & H	Iridescent.....	Brown
Riodinidae.....	<i>Apodemia mormo</i> F. & F.....	F	.....	All
	<i>Atides halesus</i> Cram.....	F & H	Iridescent.....	Dark
Lycaenidae.....	<i>Mitoura damon</i> Cram.....	F & H	Green.....	Others
	<i>Lycaena thoe</i> Guer.....	F & H	Some ?.....	Most or All
Hesperiidae.....	<i>Eueres comyntas</i> Godt. ♂ ♀.....	F	.....	All
	<i>Evergryus tityrus</i> Fabr.....	F & H	White & Light.....	Dark
Hesperiidae.....	<i>Pyrgus communis</i> Grt.....	F & H	White.....	Dark
	<i>Hesperia manitoba</i> Scud.....	F	.....	All
Sphingidae.....	<i>Smerinthus jamaicensis</i> Dru.....	F & H	.....	All
	<i>Hemaris diffinis</i> Bdv.....	F	.....	All (including dehiscent)
Sphingidae.....	<i>Celerio lineata</i> Fabr.....	F & H	Yellow & Some Pink..	Dark & Some Pink
	<i>Philosamia walkeri</i> Fld.....	F & H	Yellow sometimes ?..	Most or All
Saturniidae.....	(= <i>P. cyndia</i> auct.).....			
	<i>Actias luna</i> L.....	F & H	Few sporadically.....	Most
Saturniidae.....	<i>Hemileuca maia</i> Drury.....	F	Some White.....	Black and Some White (also abd. red)
Citheroniidae...	<i>Anisota rubicunda</i> Fabr.....	F	.....	All
	<i>Ctenucha virginica</i> Charp.....	F & H	.....	All incl. on body
Nolidae.....	<i>Celama triguetrana</i> Fitch.....	F & H	Sometimes.....	Other times
	<i>Arctiidae</i> .....	F & H	Yellow & Some Pink..	Dark & Some Pink
Arctiidae.....	<i>Eubaphis awantiaca</i> Hbn.....	F & H	.....	All
	<i>A. pantesis porthenice</i> Kirby.....	F & H	Some Yellow.....	Dark & Some Pink
Arctiidae.....	<i>Estigmene acreae</i> Drury.....	F & H	Commonly.....	When not dis'lv'd
	<i>Estigmene congrua</i> Wlk.....	F & H	.....	All
Arctiidae.....	<i>Utetheisa bella</i> L.....	F & H	.....	All
	<i>Hoplion lecontei militaris</i> Harr.....	F & H	.....	All
Agaristidae.....	<i>Alypia octomaculata</i> Fabr.....	F & H	Yellow & White.....	Dark
	<i>Phalaenidae</i> .....	F	.....	All
Phalaenidae.....	(= <i>Noctuidae</i> ).....			
	<i>Chlorizogrotis auxiliaris</i> Grt.....	F & H	Sometimes.....	Usually
Phalaenidae.....	<i>Polia assimilis</i> Morr.....	F & H	.....	All
	<i>Orthodes ovidius</i> Gn.....	F & H	.....	Fore Wing
Phalaenidae.....	<i>Graptolitha antennata</i> Wlk.....	F & H	.....	All ?
	<i>Graptolitha fagine</i> Morr.....	F & H	.....	All
Phalaenidae.....	<i>Septis arctica</i> Frr.....	F & H	.....	All

TABLE 1—Continued

FAMILY	GENUS AND SPECIES	WING	DISSOLVED BY HOT ALKALI	POSITIVE CHITOSAN TEST
	<i>Euherrichia monetifera</i> Gn.....	F & H	Hind Wing.....	Fore Wing
	<i>Prodenia ornithogalli</i> Gn.....	F & H	Hind Wing.....	Fore Wing
	<i>Euthisanotia grata</i> Fabr.....	F & H	.....	All
	<i>Psychomorpha epimenis</i> Drury.....	F & H	Yellow.....	Dark & Orange
	<i>Rhodophora gawea</i> A. & S.....	F & H	Few ?.....	Most or All
	<i>Schinia mortua</i> Grt.....	F	.....	All
	<i>Chamyris cerintha</i> Treit.....	F & H	Many of H.....	F and Some H
	<i>Hylophila bicolorana</i> Poda.....	F & H	.....	All
	<i>Autographa brassicae</i> Riley.....	F & H	.....	All
	<i>Panapoda rufimargo</i> Hbn.....	F & H	Some of H.....	Most
	<i>Plathypena scabra</i> Fabr.....	F & H	.....	All
Dioptriidae.....	<i>Phryganidia californica</i> Pack.....	F & H	Commonly.....	Commonly
	<i>Josia auriflua</i> Wlk.....	F & H	.....	Black & Yellow
Notodontidae.....	<i>Symmeristia albifrons</i> A. & S.....	F & H	.....	All
Liparidae.....	<i>Lymantria dispar</i> L. ♂ & ♀.....	F	.....	All
Lasiocampidae.....	<i>Malacosoma americana</i> Fabr.....	F	.....	All
Geometridae.....	<i>Dichorda iridaria</i> Gn.....	F	.....	All
	<i>Chlorochlamys chloroleucaria</i> Gn.....	F & H	Sometimes.....	Those remaining
	<i>Dyspteris abortivaria</i> H.-S.....	F & H	All.....	.....
	<i>Amphidasis cognataria</i> Gn.....	F & H	Some.....	Most
	<i>Ellopija fuscicollaria</i> Gn.....	F & H	.....	All
Uraniidae.....	<i>Urania fulgens</i> Bdv.....	F & H	.....	All
Lacosomidae.....	<i>Cincinnatia melsheimeri</i> Harr.....	F	.....	All
Limacodidae.....	<i>Parasa choris</i> H.-S.....	F	Green.....	Marginals
Megalopygidae.....	<i>Lagoa crispata</i> Pack.....	F	.....	All
Zygaenidae.....	<i>Harrisina</i> sp.....	F	.....	All
	<i>Zygaena charon</i> Hbn.....	F & H	.....	All
	<i>Erasmia pulchella</i> Hope.....	F & H	Iridescent.....	Others
Thyrididae.....	<i>Thyris lugubris</i> Bdv.....	F & H	.....	All
Pyrilidae.....	<i>Desmia funeralis</i> Hbn.....	F & H	White.....	Dark
	<i>Nomophila noctuella</i> D.-S.....	F & H	Hind Wing.....	Fore Wing
	<i>Pyrastria theaealis</i> Wlk.....	F	.....	All
	<i>Pyrastria farinalis</i> L.....	F & H	Commonly Some.....	Most
	<i>Crambus hastiferellus</i> Wlk.....	F & H	Few ?.....	Most or All
	<i>Galleria mellonella</i> L.....	F & H	.....	All
	<i>Ephestia kuehniella</i> Zell.....	F & H	.....	All
Pterophoridae.....	<i>Platyptilia</i> sp.....	F & H	Sometimes.....	Other times
Alucitidae.....	<i>Alucita huebneri</i> Wallen.....	F	.....	All
Olethreutidae.....	<i>Eucosma dorsisignalana</i> Clem.....	F	.....	All
	<i>Carposapsa pomonella</i> L.....	F	.....	All
Tortricidae.....	<i>Archips fumiferana</i> Clem.....	F & H	Sometimes.....	Other times
	<i>Argyrotaenia quercifoliella</i> Fitch.....	F	.....	All
Cossidae.....	<i>Prionoxystus robiniae</i> Peck.....	F & H	.....	All
Gelechiidae.....	<i>Phthorimaea operculella</i> Zell.....	F & H	Hind Wing.....	Fore Wing
Aegeriidae.....	<i>Podosesia syringae</i> Harr.....	F & H	.....	All
Stenomidae.....	<i>Stenoma</i> sp.....	F & H	.....	All
Yponomeutidae.....	<i>Atteva aurea</i> Fitch.....	F & H	.....	All
Coleophoridae.....	<i>Coleophora pruniella</i> Clem.....	F	.....	All ?
Gracillariidae.....	<i>Gracilaria bimaculatella</i> Ely.....	F & H	Hind Wing.....	Fore Wing
Acrolophidae.....	<i>Acrolophus</i> sp.....	F & H	.....	All
Tineidae.....	<i>Monopis dorsistrigella</i> Clem.....	F & H	Usually All.....	.....
Prodoxidae.....	<i>Tegeticula alba</i> Zell.....	F & H	Usually All.....	Few sometimes
Hepialidae.....	<i>Sthenopsis purpurascens</i> Pack.....	F & H	.....	All
Diptera.....	<i>Aedes aegypti</i> L.....	F	.....	All
Thysanura.....	<i>Lepisma saccharinum</i> L.....	Body	.....	All

METHODS OF CHITIN DETECTION AND SIGNIFICANCE OF  
SCALE DISSOLUTION

Chitin was originally defined as the cuticular material insoluble in hot concentrated alkali (Odier, 1823) but it has been known for a long time that this is only a preliminary definition. Actually, resistance to alkali is only relative. If the alkali treatment is sufficiently prolonged many, perhaps all, samples of chitin may be completely dispersed, as anyone can readily confirm. There is no need to give here a full review of the numerous methods that have been proposed and used for the detection of chitin (see Campbell, 1929) but it can be pointed out that although some advance has been made in the determination of the structure of the chitin found in crustacean shells (see Clark & Smith, 1936) no thorough evaluation of the various methods of detection by color reactions is possible at present since the tests have been developed and elaborated without parallel chemical analyses.

Three general methods of detection, in effect three definitions, have been more or less generally used:

1. Isolation and identification of glucosamine crystals.
2. Chitosan color reactions and sphaerite formation.
3. Color reactions following treatment with diaphanol.

Isolation of glucosamine crystals following acid hydrolysis of the suspected chitin has been used by only a few workers. It is difficult, time consuming, and requires adequate amounts of material. More seriously it does not really determine chitin but only a component of chitin, and accordingly should not be expected to necessarily differentiate between various kinds of chitin. To be sure, chitin is usually referred to as a single chemical compound (perhaps because almost all chemical studies have utilized Decapod Crustacea), but Fränkel & Jellinek (1929) have presented good evidence that the chitin of the king crab, *Limulus*, is somewhat different and we have unpublished data in agreement with their report. Yet the chitin from both *Limulus* and lobster yield glucosamine. Some species of Bryozoa appear to contain chitin since they give a violet chitosan color test but other species give a greenish "chitosan" test and so seem to contain a somewhat different polysaccharide (Richards & Cutkomp, 1946). It seems to the present author likely that chitin, like cellulose, will eventually be recognized as a group of closely related compounds.

The preparation of chitosan requires treatment of chitin with hot concentrated alkali (van Wisselingh, 1898; Campbell, 1929). As already mentioned, such methods presuppose that chitin is not destroyed, and yet we know that hot alkali can completely disperse chitin. The situation is further complicated but also partly elucidated by the conclusive demonstration that chitosan prepared from lobster chitin is not a definite predictable compound since successive preparations do not necessarily yield the same X-ray diffraction patterns (Clark & Smith, 1936). Perhaps the dissimilarity of successive samples of chitosan accounts for the difficulty the present author and others have encountered in attempting to prepare "chitosan sulfate sphaerites" (Campbell, 1929). However, even if these sphaerites were obtainable consistently they have such indefinite characteristics that by themselves they do not seem highly reliable. The iodine-sulfuric acid chitosan

color test is given by (a) preparations from *Limulus*, crustacea, insects, fungi, etc., not all of which have the same nitrogen value, and (b) by successive preparations which from the results of Clark & Smith (1936) may be presumed to vary in composition. Kühnelt (1928a) presents some evidence that chitin acts as a dispersoid in adsorbing iodine. It follows that in this color test we are dealing with a group reaction which is not sufficiently specific to be affected by minor changes in the molecules or molecular aggregates. Satisfactory evaluation of the degree of specificity must await further comparative chemical studies. With the above qualifications the method seems to be highly reliable when a positive color test is obtained.

The diaphanol method was elaborated by Schulze and his students without any chemical verification. For years the method in effect defined chitin as the cuticular material insoluble in diaphanol, and it was not until 1940 that Fraenkel & Rudall gave any validation to the basic assumption (and incidentally showed that a very long treatment is needed to obtain pure chitin by this method). The color developed on treatment with iodine and zinc chloride is evanescent; according to Kühnelt it is due to the presence of adsorbed chlorine; and certainly the method is less specific than the iodine-sulfuric acid test (despite Koch's passionate support, 1932) since it is given by chitin, chitosan and a number of other substances (see Kühnelt). The method has not found favor among workers other than the Schulze school.

The other color reactions listed by van Wisselingh and Schulze are sometimes useful for certain purposes but are not specific tests to be used for identification. X-ray diffraction analyses are good for those cases where large amounts of pure material are readily obtained but offer little or no help with minute structures where the chitin content is low. The use of enzymes may some day help with this problem but is of no assistance at present.<sup>6</sup> Such physical properties as have been studied seem to offer the biologist little help in the identification of chitin (fluorescence, birefringence, refractive index, optical rotation, specific gravity, etc.).

From the above analysis it seems apparent that it is fairly easy to demonstrate the presence of chitin in large structures that withstand the necessary preliminary drastic treatment. The fact that there may be more than one kind of chitin and chitosan only means that we are dealing with group reactions. The difficulties arise when one works with minute structures and structures which will not withstand such drastic treatment. What is the significance of dissolution of delicate structures, and what should we expect to happen in structures in which the chitin content is very low?

It is easy to show with the scales of numerous species of Lepidoptera that highly variable results are likely. Scales of some species resist prolonged alkali treatment and are still strong and of normal appear-

<sup>6</sup>Several entomologists have raised this question in talking to the author. The dissolution of a membrane known to contain chitin by digestive enzyme mixtures from bacteria or molluscs is qualitative demonstration of the existence of an enzyme to be called chitinase. However, the dissolution of a membrane of uncertain composition by a heterogeneous system containing chitinase is no proof that there is chitin present.

ance. In some other species the scales may survive the treatment in hot alkali and then vanish on transferal to water or alcohol even if the transfer is made by dilution. When a few of these scales survive (e. g., *Tegeticula alba*) they give a positive chitosan color test. Differences are also encountered between different individuals and even between different tubes run concurrently and thought to be duplicates of one another. One can only conclude that great care needs to be exercised in interpreting destruction by alkali.<sup>6</sup>

One may well ask, then, if any lepidopterous scales lack chitin. We have tried to settle this question using the most easily destroyed scales, namely the iridescent scales of *Morpho*. As pointed out in the preceding section we were unable to obtain any evidence for the presence of chitin. Being unable to obtain any evidence for the presence of chitin we are forced to conclude that it is either absent or else present in only negligible or at least undetectable percentage. The same, of course, may be said for all other arthropod membranes that are said to lack chitin (e. g., tracheoles, epicuticle).

The conclusion is that lepidopterous scales from adult wings show a long series of intermediate steps ranging from sturdy examples which are highly resistant and give strong chitosan tests, through intermediates that are more and more readily destroyed by alkali, although still containing chitin, to a few examples in which it has not been possible to show that there is any chitin.

#### THE INTERPRETATION OF ARTHROPOD CUTICLE

The work on lepidopterous scales led the author to reconsider the nomenclature dealing with the organization of the arthropod cuticle. This terminology has obviously needed revision for some years, but information is now accumulating so rapidly that it does not seem desirable to suggest a revised set of terms yet. However, it seems desirable to present a gradual change of viewpoint that is growing out of the work of Pryor, Fraenkel & Rudall, Wigglesworth and the present author. A brief resumé without references has appeared in *Science*, (Richards, 1947).

It is generally considered that the exoskeleton of insects, crustacea, arachnids and other arthropods is composed primarily of a polysaccharide called chitin, with or without the additional statement that other substances such as proteins, lime, pigments and an external waxy layer are present. In fact, textbooks usually characterize this cuticle simply as "a chitinous exoskeleton." This general viewpoint is lucidly stated by Ferris and Chamberlin (1928), "by the very definition of it, chitin is the basic substance of which the non-cellular body wall is composed. The entire body wall, membranous and hard, is basically composed of chitin and this chitin serves as the carrier in which other substances are deposited. The body wall is not some other substance permeated with chitin, it is chitin permeated with other substances." If we ignore as irrelevant to our discussion the old argument of whether the term "chitin" is to be used in its original chemical sense or in the

<sup>6</sup>Whether this ready dissolution is due to delicacy of structure or to low percentage of chitin present is uncertain. See also Richards & Korda (1947).

subsequent anatomical sense and adopt the term in its current chemical sense, then seldom does one find any statement to conflict with the above quotation. Wigglesworth (1939) avoids making any implication by referring to chitin as "the best known constituent of the cuticle." In hundreds of papers reviewed by the present author only one has been found relegating chitin to a secondary position: Forbes (1930) in discussing the chemical versus the anatomical usage of the term says, "... the chemists' chitin is in fact a secondary constituent of the insect skeleton . . . the soft transparent 'filler'." We have, then, two possible viewpoints which differ primarily in whether the chemical chitin is to be considered the primary or a secondary component of arthropod cuticle.

First, let us evaluate the evidence in favor of chitin being the basic component of arthropod cuticle. This generally accepted viewpoint seems to be based on the remarkable chemical stability and insolubility of chitin, the retention of recognizable structure after the removal of other components and the presumed general occurrence of chitin throughout the phylum Arthropoda. The fact that it is a more or less well-characterized chemical compound probably also contributes to its being considered in contrast to less well-known components.

Chemical stability and insolubility can be dismissed summarily as properties of the compound which are not relevant to the question of whether or not chitin is the basic component of arthropod cuticle.

Recognizable anatomy after purification, although suggestive, is also not proof because: (1) *chitin is insoluble in the agents used for purification*; (2) electron microscope studies show that it is only the grosser microscopic anatomy which is retained after purification (Richards & Korda, 1947) and, (3) X-ray diffraction studies show that the chitin micelles do not retain their arrangement (Fraenkel & Rudall, 1940). The x-ray diffraction data and even better the electron microscope pictures show such extensive changes in the arrangement of the chitin units that it is not possible to view the chitin micelles as constituting a molecular framework in the interstices of which other components are imbedded. Actually, it is a gratuitous assumption for any one to have said that the other components are added to chitin simply because the alkali insoluble fraction retains its gross anatomy after purification *with alkali*. Yet this *non sequitor* appears to be one of the major reasons for considering the arthropod cuticle as primarily chitinous!

It is said that the arthropod cuticle always contains chitin but this is not entirely true. Numerous membranes of arthropods contain no demonstrable chitin, and even the general exoskeleton in the early stages of its development lacks chitin. It seems advisable to give a resumé of some of the facts concerning certain of these non-chitinous membranes.

It is well known that all of the tracheae of some insects are completely dispersed by hot alkali whereas the larger tracheae of other insects are not dissolved and give the various color tests thought to be specific for chitin (Campbell, 1929). In all insects studied, the smaller tracheal branches are destroyed by hot alkali. Yet there is fundamental structural similarity between tracheae with chitin and tracheae



without chitin.<sup>7</sup> It seems to the present author that this would be unlikely if chitin were a basic component *determining* the type of membrane structure. The same may be said for lepidopterous scales which have been discussed in the previous sections of this paper.

Then there is the classical and universally accepted case of the epicuticle. The well-known work of Kuhnelt (1928b), Yonge (1932), Wigglesworth (1933), Pryor (1940) and Drach (1939) shows that the outer layer of the developing cuticle of insects and crustacea is laid down as a protein sheet which usually but not always (e. g., numerous aquatic and semi-aquatic larvae) becomes "waterproofed" by the addition of lipids but never acquires any demonstrable chitin. Layers formed later (exocuticle and endocuticle) contain both protein and chitin. Data given in the present paper show that the same is true for tracheae (*Blatta orientalis*) and moth scales (*Galleria mellonella*) in species in which these structures contain chitin in the fully developed adult.

There are also some other non-chitinous membranes but no emphasis will be placed on them since one can question the validity of homologizing them with cuticle (insect egg shells, cockroach egg capsules). The neural lamella appears to be a plasticized protein layer without chitin but it has a different origin (Richards, 1944). The endosternite of certain arachnids is too little known for discussion but it too is said to consist of protein without chitin (Mathews, 1923).

And, finally, even so-called chitinous membranes may have a very low percentage of chitin. The actual percentage of chitin in the cuticle of the general exoskeleton is usually in the range of 20-40 per cent of the dry weight. Although it may rise to a high value of 60 per cent (Fraenkel & Rudall, 1940) it may also fall to the low value of 1.4-2.3 per cent (Pepper & Hastings, 1943). Recently Rosedale (1945) has recorded the absence of chitin from the exoskeleton of an African insect but the present author finds this paper so difficult to evaluate that the case is not stressed. A "basic component" does not necessarily have to represent a majority of the material present (as Forbes claims), but it is difficult to conceive of "the basic component" accounting for only 1.4 per cent of the total weight.

We must conclude, then, that the evidence for calling the arthropod cuticle primarily chitinous is, to say the least, not impressive. There is as valid evidence for calling the arthropod cuticle chitinous only the nearly general presence of chitin. But we have seen that this generality has numerous exceptions. It stretches one's credulity to view chitin as the primary and necessarily primary component when it ranges from 60 per cent down to nearly or actually zero per cent, and when membranes (e. g., tracheae) may show the same fundamental structure whether chitin is present or absent. It seems to the present author inescapable that either there is no chemical constancy to arthropod cuticle or that the basic components must be ones other than chitin which are always present in reasonably high percentages.

<sup>7</sup>There seems to be no reason to think the structure of tracheal walls differs in any fundamental respect from that of the exoskeleton. Incidentally, we have recently discovered setae with a cuticle the structure of which resembles that of a tracheal wall with its helical taenidial thickenings (unpublished). Conversely, in Myriapods the tracheal invaginations form the endoskeleton (Voges, 1916).

Having considered the evidence for calling the arthropod cuticle basically chitinous—and finding it not convincing—let us examine the other known components and see if any of them are free from the objections raised above. Since we have pointed out that chemical stability and insolubility are not valid reasons for considering chitin basic, it follows that we are free to consider more soluble and less stable compounds. One component or rather group of compounds immediately stands out as being universally present in reasonably high percentage in all these cuticular membranes. These are the proteins. They are present in a plasticized state but are rather readily removed (Pryor, 1940; Fraenkel & Rudall, 1940).

There is no known authentic case of chitin occurring in any arthropod membrane without at least protein also being present. Even in the case of the peritrophic membrane of insects (the homology of which is arguable), which is commonly referred to as pure or nearly pure chitin, the reports of the most reliable workers state that protein is present (Wigglesworth, 1930, 1939). Any one experienced in making these tests will realize why it is so much easier to demonstrate chitin in the peritrophic membrane than it is to demonstrate protein (difficulty of cleaning without removal of protein). Membranes without chitin always have a large percentage of protein. Even membranes with a high percentage of chitin also have a high percentage of protein (Fraenkel & Rudall, 1940).

There is only one preliminary paper attempting to characterize the proteins of arthropod cuticle (Trim, 1941). This paper indicates that the chemical composition of these proteins resembles most closely that of silk and that several somewhat different proteins may be present even in one species (but then it seems likely that there are several different kinds of chitin despite oft-repeated statements to the contrary). Clearly further work on the composition of cuticular proteins and on their physiological significance in the arthropod exoskeleton is needed.

Since plasticized proteins are always present, viewing the cuticle as primarily a protein sheet allows, for instance, considering all tracheae as having the same basic organization whereas viewing the cuticle as primarily chitinous forces us to say that some tracheae consist of only a non-chitinous epicuticle while other tracheae consist of a non-chitinous epicuticle plus an underlying chitinous endocuticle. The same may be said for butterfly and moth scales. Of more practical significance, the same may also be said for the epicuticle and endocuticle of the exoskeleton. On the basis of viewing the cuticle as primarily chitinous the epicuticle has to be viewed as something fundamentally different plastered onto the outer surface of the cuticle. And yet there is no demonstrable discontinuity between epicuticle and endocuticle in development.<sup>8</sup> Viewing the cuticle as primarily a plasticized protein layer permits considering the epicuticle as simply the outer layer of a continuous cuticle—as indeed it seems to be (Wigglesworth, 1933; Richards & Anderson, 1942).

The other more or less regular components that are known are so sporadic in occurrence and appear so late in development that no one

<sup>8</sup>The fact that one can manually separate the epicuticle and endocuticle as intact sheets (e. g., after digesting with pepsin) is of no particular significance. One can also separate both the epicuticle and endocuticle into sub-sheets in some cases.

views them as necessary constituents. Clearly they, especially lime and pigments, are additions to a basic membrane structure and need not be considered further here. In at least a few cases other material may be secondarily laid down as another more or less complete layer on top of (outside of) the cuticle proper (Kühnelt, 1928b; Wigglesworth, 1946), but these cases are obvious additions which do not affect the question of how the cuticle is organized as a rule.

In conclusion: if we accept the view that there is a fundamental similarity running through the cuticle of arthropods, then we have the choice of two viewpoints. We can say that there is a chitinous exoskeleton in which case we focus attention on an almost but not entirely universal component of great stability but have to admit a number of exceptions and face the criticism outlined above, criticisms that seem to be invalidating. Or we can say that there is a protein exoskeleton which can be viewed as a single plasticized protein sheet usually subdivided by the addition of waxes on the outer surface and chitin in the bulk of the sub-surface region (and commonly later impregnated with lime and pigments and further polymerized to give the typical laminar structure including sub-layers within both epicuticle and endocuticle). Since the idea that chitin is the primary component seems to be based in large part on the erroneous assumption that this is proved by the retention of structure after purification in reagents in which chitin is not soluble, it would seem just as reasonable to pick any other equally widely distributed component. The valid and relevant facts are: 1. proteins have been shown to be present in high percentage in cuticular structures whenever proper tests have been made, 2. chitin is usually but not always present, 3. in development a clearly recognizable protein layer precedes the formation of an underlying protein-chitin layer, 4. fundamentally similar cuticular structures occur with or without chitin, and 5. other components (e. g., lime) occur only sporadically even though they may be found in several groups. When the chemical components are considered in this light one is immediately impressed with the fact that it is the plasticized proteins which are always present in high percentage and that viewing the arthropod cuticle as a plasticized protein sheet variously modified by additional substances (usually but not always including chitin) allows a unified interpretation of all known manifestations of these cuticles, both internal and external, whereas viewing it as primarily a chitinous sheet does not.

In an analysis of this sort there is a tendency to oversimplify. Actually the arthropod exoskeleton, as is well known, exhibits a large number of variant forms. These differences from group to group and from species to species remain as facts irrespective of how we try to collate the variations. The point of the present section is to call general attention to the untenability of the concept implied by the term "chitinous exoskeleton" and to present a somewhat different view that more closely represents the facts.

#### SUMMARY

1. Lepidopterous scales vary from structures strongly resistant to alkali and oxidizing agents and positive for chitin tests through a series of more and more delicate forms in which it is difficult to demonstrate

chitin to a few forms which are consistently negative to chitin tests. Most lepidopterous scales therefore contain more or less chitin but some appear to have a negligible percentage or none.

2. Methods of chitin detection are discussed with respect to the difficulty of interpreting negative tests. There is as much reason for saying some lepidopterous scales lack chitin as there is for saying any arthropod structure lacks chitin.

3. The organization of arthropod cuticle is discussed. It is pointed out that the concept implied by the term "chitinous exoskeleton" is not consistent with the known facts. It seems more nearly correct to view arthropod cuticle as a plasticized protein sheet variously subdivided by the addition of waxes (usually) on the outer surface and of chitin (usually) in the inner parts and commonly later impregnated with lime and pigments and further polymerized with polyphenols to give a laminar structure within both epicuticle and endocuticle.

#### SUPPLEMENTARY NOTE

Since the present paper was submitted for publication another important paper has appeared by Fraenkel and Rudall (Proc. Roy. Soc. London, ser. B, 134: 111-143, 1947). These authors suggest that the basis of arthropod cuticle structure consists of alternating monolayers of chitin and protein. This calls for a weight ratio of 45% protein and 55% chitin. In the five representatives of soft cuticle studied they found a range from 44-61% chitin. In hard cuticles one might expect more deviation and, indeed, chitin percentages as low as 24% were recorded in their analyses. These authors overlooked the paper by Pepper and Hastings (1943) in which a chitin percentage of 1.5-2.5 was recorded for the soft body cuticle of *Loxostege* larvae.

The data presented in the above paper are not readily compared with the data given in the present paper. Both papers emphasize the difficulty of determining the percentage of chitin present. Fraenkel and Rudall attempt to formulate a basic model of alternating monolayers. This viewpoint leaves no room for soft cuticles of low chitin content and ignores membranes which lack chitin. To defend this viewpoint at the present one has to disregard membranes lacking chitin and assume that low chitin figures such as those given by Pepper and Hastings are in error either because of relative thinness of the endocuticle layer or because of unintentional removal of a large portion of the chitobiose units. The present paper is based on rationalizations proceeding from acceptance of the idea that structures of similar appearance may contain much, little or no chitin. At present there is no certain way to resolve the discrepancy in viewpoint but it seems not inconceivable that both might be correct; that is, the cuticle may be developmentally a modified protein sheet, with the alternating monolayer concept representing the commonest, and perhaps the best, basic model for the *inner part* of the cuticle (endocuticle).

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## SOME SOUTHWESTERN GRYLLACRIDIDAE (ORTHOPTERA)

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Collecting in New Mexico during the summer of 1945 resulted in the discovery of three new species of the orthopterous family Gryllacrididae. One of these is a *Ceuthophilus*; the other two belong to the little known genera *Ammobaenetes* and *Daihiniodes*. To Dr. T. H. Hubbell I am indebted for the loan of material of *Daihiniodes hastiferum* (Rehn) and a pair of *Ammobaenetes phrixocnemoides* which he had compared with Caudell's type. Inasmuch as the type of *A. phrixocnemoides* is a female from Mesilla Park, New Mexico, and Hubbell's specimens are from Oklahoma there is still a possibility that the two regions harbor more than a single species but discovery of adult males from Mesilla Park is necessary for complete solution of the matter. Nevertheless, the specimens treated below seem certainly to represent a new form for which taxonomic practice requires a name even though further collecting may reveal it to be a subspecies.

### *Ammobaenetes arenicolus*, new species

*Type:* Male, White Sands, New Mexico, June 24, 1945.

About the size of *A. phrixocnemoides* (Caudell, as determined by Hubbell) and very similar to that species in structure. Fastigium of vertex broadly carinate, united with facial fastigium. Interocular distance about twice the long diameter of eye. Front coxa with a short, acute tooth. Front femur with a rather long pregenicular spur on ventrocephalic carina, this spur preceded by a much shorter one. Front tibia stout, subcylindrical, armed on ventrocaudal carina with three long, sharp spurs (exclusive of calcars), on ventrocephalic carina with three similar but smaller spurs. Ventral calcars large, subequal, the caudal one a little the larger. Dorsocaudal calcar about three-fourths as long as ventrocaudal; dorsocephalic calcar short and very slender. Middle coxa unarmed. Middle femur with two slender preapical spurs on ventrocephalic carina and a shorter genicular spur on ventrocaudal carina. Middle tibia with four moderate size spurs on each dorsal carina and three smaller spurs on each ventral carina; caudal calcars larger than corresponding cephalic ones. Hind femur unarmed, its lower margin nearly straight, its upper margin suddenly sloping in apical third. Hind tibia with upper and lower surfaces nearly parallel to apical two-fifths, thence convergent to apex by curvature of upper margin. Dorsocephalic carina with eight spurs (exclusive of calcars). Of these spurs the distal five are very long and crowded. Dorsocaudal margin of hind tibia with eight spurs similarly arranged. Both upper margins of the hind tibia bear small denticles between the more proximal spurs. First joint of hind tarsus prolonged beneath at apex into a

stout spine, which is preceded by a very small spine. Second joint spinose beneath. Subgenital plate broadly emarginate at apex; laterally it is briefly produced as membranous, digitiform lobes. Pseudosternite with a flange on caudal face, its cephalic lobe with four transverse rugae. The pseudosternite, as also the whole exoskeleton, is rather lightly sclerotized.



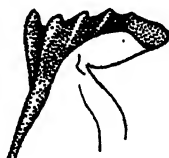
1a



1b



2a



2b

FIG. 1a. *Ammobaenetes phrixocnemoides* (Caudell). Pseudosternite of male, caudal view.

FIG. 1b. *Ammobaenetes phrixocnemoides* (Caudell). Pseudosternite of male, lateral view.

FIG. 2a. *Ammobaenetes arenicolus* new species. Pseudosternite of male, caudal view.

FIG. 2b. *Ammobaenetes arenicolus* new species. Pseudosternite of male, lateral view.

The insect is wholly colorless, in live a translucent white, this changing to chalk-white after drying from preservative. The eyes are black and the spurs and spines are reddish but unpigmented. Length of body 15 mm.; of pronotum 3.5 mm.; of hind femur 10 mm.

*Allotype*: Female, data as for type.

Similar to type except for sexual structures of abdominal apex. Ovipositor similar to that of *phrixocnemoides* (Caudell) and *lariversi* Strohecker. Length of body 19 mm.; of pronotum 4 mm.; of hind femur 10.5 mm.; of ovipositor 7 mm.

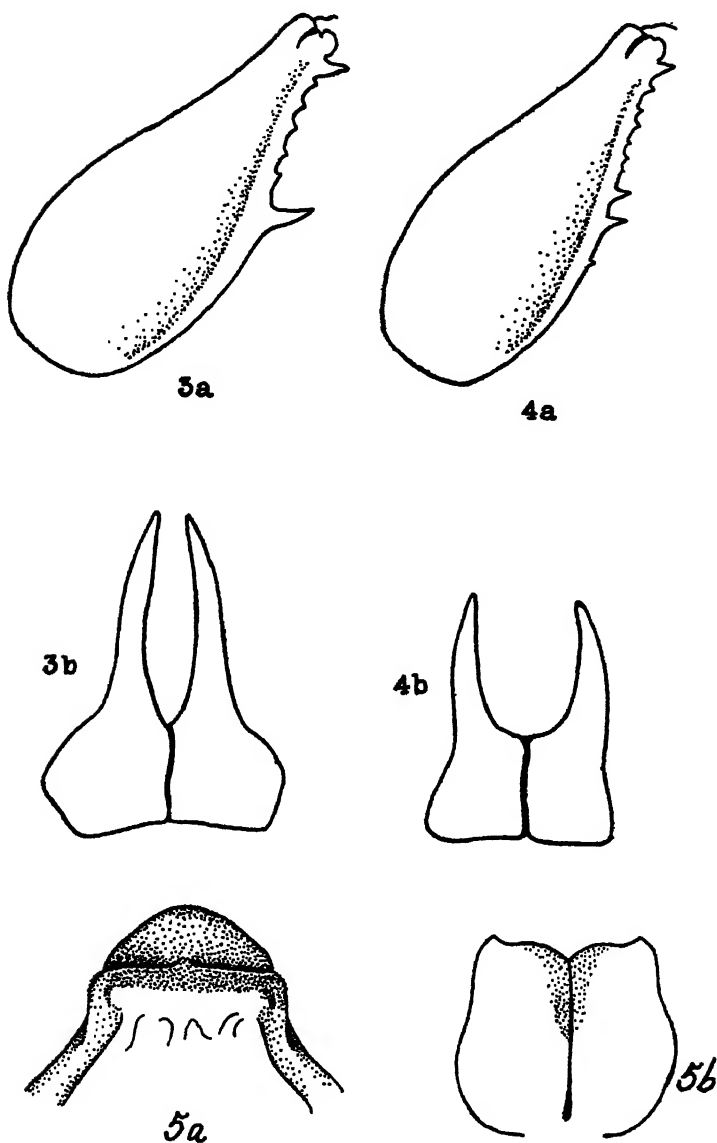


FIG. 3a. *Daikiniodes hastiferum* (Rehn). Hind femur of male (Torrence Co., New Mexico).

FIG. 3b. *Daikiniodes hastiferum* (Rehn). Subgenital plate of male.

FIG. 4a. *Daikiniodes larvale* new species. Hind femur of male.

FIG. 4b. *Daikiniodes larvale* new species. Subgenital plate of male.

FIG. 5a. *Ceuthophilus leptopus* new species. Pseudosternite of type, caudal view.

FIG. 5b. *Ceuthophilus leptopus* new species. Subgenital plate of type.



In addition to these two specimens fifty-one males and thirty-eight females are designated paratypes. There is a considerable degree of conformity in size but one male has the following measurements: pronotum 3 mm.; hind femur 8.5 mm.

The three species now described may be differentiated:

1. Caudal metatarsus longer than following two joints together, not spinose beneath..... *lariversi* Strohecker
2. Third joint of hind tarsus longer than first two together ..... 2
2. Flange of pseudosternite about one-third as high as broad, broadly emarginate dorsally. Tergites with definite color pattern, *phrixocnemoides* (Caudell)
- Flange of pseudosternite about one-fifth as high as broad, evenly arcuate dorsally. Insect entirely white except eyes..... *arenicolus* n. sp.

### *Daihiniodes larvale*, new species

*Type*: Male, White Sands, New Mexico, June 20, 1946.

In size about equal to *D. hastiferum* (Rehn) and similar in structure but not so heavily sclerotized and with hind femur less massive. Left front femur with seven denticles on ventrocephalic carina; the right femur has but five. The front tibia is much as in *Ammobaenetes*. Front tarsus three-jointed, the first two joints acutely spinose beneath. Middle tibia with two spurs in distal half of ventrocephalic carina together with several small spines. Ventrocaudal carina with a few small spines. There is an internal (caudal) genicular spur. Caudal femur (left) stout, its upper carina with a row of denticles, its ventrocephalic carina with twelve stout spines, the first of which is located just before the middle. Following the first spine are two somewhat larger than the others but not attaining such disproportionate size as the large femoral spine in *D. hastiferum*. Hind tibia much as in *hastiferum*, not so strongly bowed and with spurs more slender. Subgenital plate with its lateral apices produced into digitiform processes which are little longer than the basal part of the plate. In life translucent china-white; chalk-white after drying from alcohol and xylol.

Length of body 23 mm.; of pronotum 6 mm.; of hind femur 15 mm.

*Allotype*: Female, data as for type.

Differing from type only in size and in characters of hind femur and apex of abdomen. Hind femur with a row of denticles on ventrocephalic carina. Ovipositor short, moderately stout, its dorsal valves attenuate and aciculate at apex. Ventral valves with four sharp teeth (including apical hook).

Length of body 17 mm.; of pronotum 5 mm.; of hind femur 11.5 mm.

In this study eighteen males and eight females (all paratypes) have been examined in addition to the type and allotype. Most of these were collected June 24, 1945, and due to a delay in properly preserving them are brown rather than clear white.

Comparison of the above series of *larvale* with a small series of four males and one female of *hastiferum* shows only slight but apparently constant structural differences. The development of the large tooth on the hind femur of *hastiferum* does not seem to be an "orthogenetic" character. It is as decided in small as in large males. The relative sizes of the femoral spines in the males of *larvale* holds for the entire series of males. With both species at hand the difference in degree of sclerotization is evident and the lack of color in *larvale* is a very striking

feature. The differences in pseudosternites of the two species is wholly quantitative, i. e., due to a greater sclerotization of the structure in *hastiferum*.

The two species, *D. larvale* and *A. arenicolus* were collected at night, the former mostly at the edges of the "flats," the latter mostly on the dunes. Both were observed feeding on *Ephedra* cones in the small windrows of the flats. The *Ammobaenetes* was very abundant, occurring by scores or even hundreds within a small area. Specimens of the *Daiknoides* were encountered infrequently. Attempts at continuous observations on the insects were largely unsuccessful. When they were placed in an apparently suitable environment in the laboratory they soon died.

### *Ceuthophilus leptopus*, new species

*Type:* Male, Dripping Springs Canyon, Organ Mts., New Mexico, August, 1945.

A slender-bodied, long-legged form which apparently is closest to *yavapai* Hubbell. Fastigium of vertex slightly elevated, rounded at apex and feebly impressed above. Interocular space twice or more as great as long diameter of eye. Front coxa toothed; middle coxa unarmed, its lower angle obtuse. Front femur with two widely spaced spurs on ventrocephalic carina. Middle femur with three or four small spurs on each ventral carina. Hind femur slender, evenly tapering with each ventral carina denticulate along its whole length. The distal third of the femur is denticulate above and at the sides. Hind tibia straight or very feebly undulate, its dorsocaudal calcar three-fourths as long as metatarsus. Tarsus slender, metatarsus almost as long as following three joints together; claws short. Ventral keel of metatarsus non-setose. Ninth tergite with a membranous area at apex upon which are coarse setae. Epiproct depressed, broadly and deeply grooved, shallowly emarginate at apex. Paraprocts membranous, probably bulbous in life. Subgenital plate divided, about as broad as long, its mesodistal portion membranous. Pseudosternite with a flange across dorsum. This flange is almost straight across its top, a little angulate at middle and finely crenulate along its entire extent. Cephalic lobe rounded but subtriangular. Ventral rami well sclerotized, columnar. Length of pronotum 3.5 mm.; of front femur 7 mm.; of hind femur 14 mm.

*Allotype:* Female, data as for type.

Agreeing in all respects to the male type except for the terminal abdominal structures. The denticles on the ventral carinae of the hind femur are smaller than in the male. Subgenital plate simple, rounded. Ovipositor long and slender, its dorsal valves aciculate at apex but very little upturned. Ventral valves armed with five (including hook) subtriangular teeth. Length of pronotum 4 mm.; of front femur 7 mm.; of hind femur 14 mm.; of ovipositor 11.5 mm.

The specimens were collected in molasses traps in the fairly mesic upper portion of the canyon. Several weeks elapsed between the setting and recovery of the traps and all the specimens had evidently been in the fluid for some time since there is little left of them but the chitinous shell. The coloration is not definite enough to be described

but there is some indication of a *pallidus* pattern, i. e., the pronotum shows evidence of a large pale area on each side and there are other suggestions of pale maculae on a darker ground. The insect is almost glabrous, setae being fine and sparse, and feebly polished.

Three males and six females taken with the type and allotype are designated paratypes.

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STATISTICAL METHODS: APPLIED TO EXPERIMENTS IN AGRICULTURE AND BIOLOGY, by GEORGE W. SNEDECOR. Ames, Iowa State College Press, 1946. Pp. xvi+485. Price \$4.50.

This is the fourth edition of this well-known work, which has been widely used in the fields of agriculture and biological research since its first appearance in 1937. The general order of presentation is the same as before: simple variation and correlation, some large sample theory and more complex cases of chi-square, analysis of variance and covariance, multiple and curvilinear regression, and more complex concepts. There has been considerable minor rearrangement, and new emphasis has been placed on sampling, fiducial limits, estimation, and components of variance. The format is somewhat more attractive than in previous editions.

The book begins with several new sections on sampling of attributes, considerably more imposing than the former very elementary opening. A table of fiducial limits for binomial material is introduced (its theory being left to Chap. 16). There is also a new and useful table of random numbers. Some of the ideas brought out in the former Chapter 1 are then developed. Other chapters show less difference from former editions, but in all there are changes. Graphic tests of significance are omitted from Chapters 2 and 4, and mathematical tests are treated more exhaustively. Fundamentals of regression and correlation are more fully discussed, and the Z-transformation is introduced. Chapter 9, on chi-square, contains some material originally in Chapter 1, as well as some new material. The chapters on analysis of variance contain material on basic assumptions, components, and disproportionate frequencies, not in older editions. Later chapters have fewer changes, but there is more attention to Gauss multipliers and more detail in discussion of single degrees of freedom, while the section on errors of "betas" is omitted. An obvious error in Example 14.7 is retained. Some familiar problems and sections are omitted and some new ones introduced.

These changes show the influence of development in the knowledge of statistics and of the work of associates on the strong staff at Ames. The book retains many of the characteristics of earlier editions. The informal language with its personal pronouns, adding to readability; the effort to develop logic "painlessly"; the presentation of tables in a form to appeal to experimenters more than to mathematicians; the strong practical emphasis and wealth of practical problems are all there. Analysis of variance is strongly emphasized, and other techniques are related to it. The close relation of the author's laboratory to experimental work in various fields is well reflected. Difficult questions are handled in an apparently easy manner, reversing the practice in some texts.

The changes superimposed on the former development have made logical outlining a little difficult. The text is definitely more valuable as a reference than earlier editions and seems more difficult to adapt to teaching. In studying and using the text, the scientific worker will feel anew the influence of the modest and unselfish work of the author and his associates, which has already contributed so much to progress.—F. M. WADLEY.

# NOTES ON YPIRANGATHEMIS SANTOS (ODONATA: LIBELLULIDAE) WITH A DESCRIPTION OF THE FEMALE OF Y. CALVERTI SANTOS

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The genus *Ypirangathemis* was described by Santos (1945) from four males, which he described as *Y. calverti*, n. sp. On the basis of wing venation and the structure of the male genitalia, Santos believed *Ypirangathemis* to be closely related to *Erythrodiplax* Brauer and to *Tarnetrum* Needham and Fisher.

Through the kindness of Dr. Erich Schmidt of Bonn, Germany, the writer has been able to study a series of 16 ♂ and 5 ♀ which are unquestionably *Y. calverti*. Through a study of this material, and additional material in other genera (particularly *Erythrodiplax* Brauer, *Uracis* Rambur, *Tarnetrum* Needham and Fisher, and *Sympetrum* Newman), it has been possible to understand something of the relationships of *Ypirangathemis*. Specimens of the series received from Dr. Schmidt have also been examined by Dr. P. P. Calvert.

The writer is indebted to Dr. Schmidt, Dr. C. H. Kennedy of Ohio State University, and the Museum of Zoology of the University of Michigan, for the loan of material for study; and to Dr. Calvert for his comments on the identity and relationships of the *Ypirangathemis* material.

## DESCRIPTION OF YPIRANGATHEMIS CALVERTI SANTOS

*Allotype Female.* Face largely metallic bluish; central and lateral portion of frons brownish, anteclypeus and base of labium very dark brown. Frons with median groove shallow and anterior carina but slightly developed, in profile more or less rounded; vertex and occiput rounded. Rear of head metallic blue-black, with a small, rounded, dark brown spot on each side next to compound eye.

Prothorax black, with a narrow, yellowish, dorsal longitudinal stripe; posterior lobe of prothorax quadrately rounded, not erect, its free edge with a few short hairs. Remainder of thorax largely yellowish brown, the venter black, the dorsum and sides marked with black as follows: dorsum (mesal portion of mesepisternum) black anterior to dorsal carina on either side of a median yellowish longitudinal stripe, the black grading posteriorly into a series of transverse lines, the lines covering dorsum on either side of dorsal carina and extending about halfway to humeral suture (a few of these transverse lines extend laterally to the humeral suture, as dark brown rather than black lines); sides of thorax just above bases of legs black; a narrow brownish black line along humeral suture, the line somewhat wider dorsally; a narrow brownish

black line along suture between mesepimeron and metepisternum, the line widening at its dorsal end; a short brownish black line just in front of spiracle, extending about halfway up side of thorax; spiracle black; a broad brownish black band extending vertically across metepimeron, and fading out dorsally. Legs black, tarsal claw small, located a little beyond middle of claw, 10-12 spines on outer angle of hind femur, proximal spines very short, the spines gradually increasing in length distally, penultimate spine about half as long as ultimate spine. Wings hyaline, with a dark spot on each wing between nodus and stigma, as in fig 5; venation essentially similar to that in fig. 5; stigma yellowish.

Abdomen black, with a brownish longitudinal lateral stripe which extends from segment 2 to about the middle of segment 7; this stripe occupies a little over half the dorso-ventral width of the segment on 2, and gradually narrows posteriorly; it is interrupted by a fine black line along the transverse carinae of 2 and 3, and where the carina would be on 4, and by broader black lines at the intersegmental rings.

Vulvar lamina (see fig. 2) long and trough-shaped, in profile narrowing distally and rounded apically, and extending beyond apex of abdomen; vulvar lamina extending ventro-caudad at an angle of about 30° or less with the horizontal. Sternite of segment 9 drawn out into a pair of closely approximated blade-like structures which extend as far caudad as the vulvar lamina; gonapophyses appearing as two small finger-like processes at base of ninth sternite.

Hind wing 22.0 mm., abdomen 18.0 mm., stigma 3.7 mm.

The allotype female is somewhat teneral, and teneral males are similar to teneral females in color. With increasing age the dark color on the body spreads—backward over the thorax and forward over the abdomen—until in the fully adult specimen the entire body is bluish black, with a light blue pruinescence.

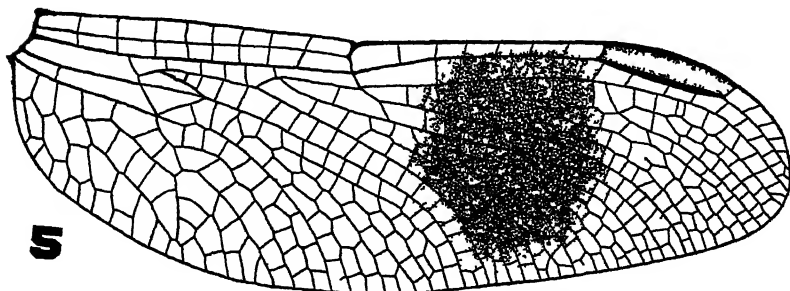
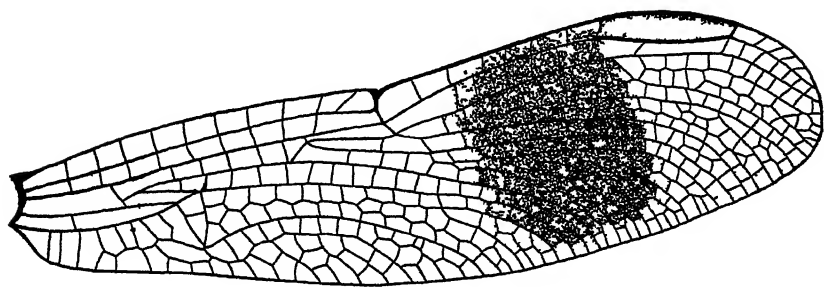
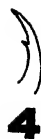
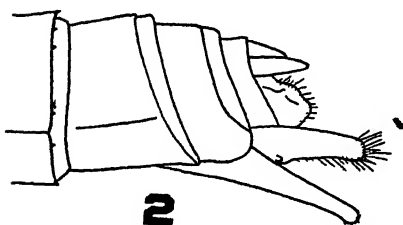
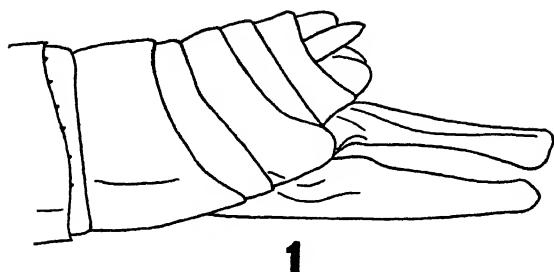
*Wing Venation.* The following tabulation is based on 16 ♂ and 5 ♀, and the numbers in parentheses refer to the number of wings (out of 42) in which the character occurred.

Antenodals in front wing,  $7\frac{1}{2}$  (1), 8 (1),  $8\frac{1}{2}$  (11),  $9\frac{1}{2}$  (25), or  $10\frac{1}{2}$  (4); postnodals in front wing, 6 (2), 7 (13), 8 (15), 9 (8), or 10 (4); triangle in front wing with costal side straight (24) or slightly broken distally (18), and crossed (40) or free (2); subtriangle in front wing 1-celled (3), 2-celled (15), 3-celled (23), or 4-celled (1); discoidal field of front wing with 2 (27) or 3 (15) cells bordering triangle, followed by 2 (42) cell rows, increasing to 5 (2), 6 (13), 7 (19), or 8 (8) margin,

#### EXPLANATION OF PLATE I

FIG. 1. *Uracis fastigiata* (Burmeister), terminal abdominal segments of ♀, lateral view. Buenavista, Sta. Cruz, Bolivia, Jan. 1946 (Coll. C. H. Kennedy.) FIG. 2. *Ypirangthemis calverti* Santos, terminal abdominal segments of ♀, lateral view; allotype ♀, São Bernardo, São Paulo, Brazil, 25 January 1933 (Coll. E. Schmidt). FIG. 3. *Y. calverti*, hind femur of ♂, lateral view; No. 1, São Bernardo, São Paulo, Brazil, 25 January 1933 (Coll. E. Schmidt). FIG. 4. *Y. calverti*, tarsal claw; No. 1, São Bernardo, São Paulo, Brazil, 25 January 1933 (Coll. E. Schmidt). FIG. 5. *Y. calverti*, wings of ♂; No. 2, São Bernardo, São Paulo, Brazil, 25 January 1933 (Coll. E. Schmidt).

Figures 1-4 drawn with camera lucida, figure 5 drawn with projection apparatus.



cells; antenodals in hind wing, 7 (12),  $7\frac{1}{2}$  (2), 8 (24),  $8\frac{1}{2}$  (2), 9 (1), or  $9\frac{1}{2}$  (1); postnodals in hind wing, 6 (1), 7 (8), 8 (19), 9 (11), or 10 (3); triangle in hind wing free (30) or with 1 (11) or 3 (1) crossveins, base of triangle opposite arculus (42); CuP (Cu<sub>1</sub>) in hind wing arising at anal angle of triangle (36) or slightly separated from anal angle of triangle (6); 1 (28) or 2 (14) cells in anal loop between base of A<sub>1</sub> and Aspl (bisector of loop); 1 (41) or 2 (1) cubito-anal crossveins in both front and hind wings; 1 (41) or 2 (1) bridge cross-veins in both front and hind wings; supratriangle in front wing free (39) or with one crossvein (3); supratriangle in hind wing free (41) or with one crossvein (1); arculus in front wing slightly proximal to second antenodal (8), opposite second antenodal (20), or slightly distal to second antenodal (14); arculus in hind wing slightly proximal to second antenodal (1), opposite second antenodal (2), up to one-fourth cell length beyond second antenodal (20), or one-fourth to one-half cell length beyond second antenodal (19); hind wing with 2 (42) rows of postloop cells in anal field.

Other features of the wing venation are shown in fig. 5.

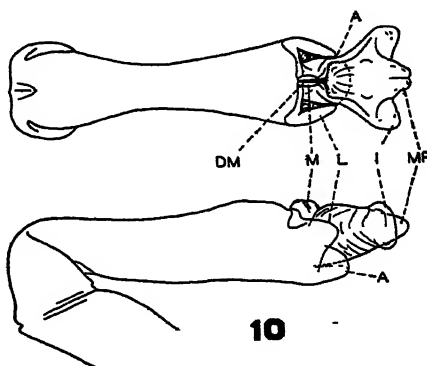
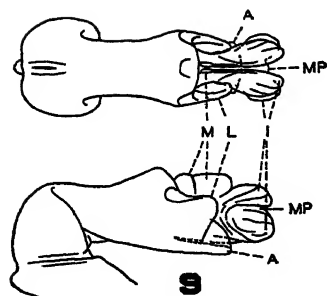
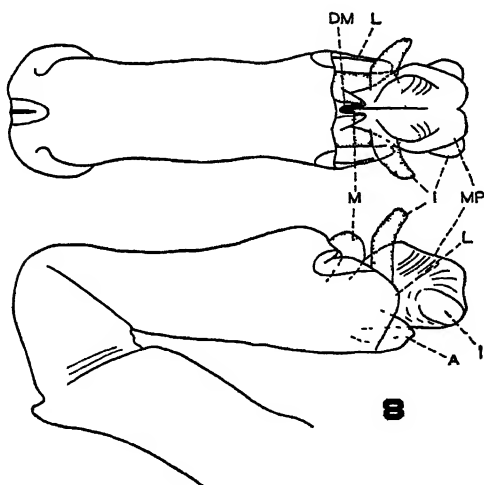
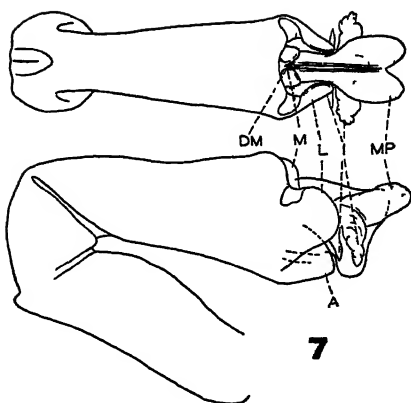
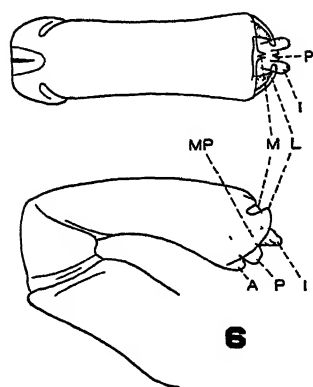
**Male Genitalia.** Segment 2 with anterior lamina low-lying, its free edge broadly U-shaped in ventral view; genital lobe strongly overlying posteriorly, its distal margin truncate; hamules about as high as genital lobe, in profile appearing elongate and broadly rounded apically, but actually with a small curved inner branch that is apparent only in ventral view. Superior appendages relatively short, the sharply pointed apex very slightly recurved; inferior angle prominent, with three or four small teeth just proximal to inferior angle; inferior appendage nearly as long as superiors. Penis as in fig. 6: terminal segment 1.0–1.1 mm. in length (from anterior meatus of seminal duct on penultimate segment, to apex of lateral lobes), and slightly swollen distally; lateral lobes somewhat triangular in profile, with the apex drawn out and rounded and directed ventrad; medial lobes small; median process small but complex, in the non-erect penis not extending beyond apex of lateral lobes; a pair of internal lobes located laterally at apex of median process, and another lobe (probably a posterior lobe; fig. 6, P) arising from dorsal side of base of median process; this latter lobe is bilobed apically, and is probably erectile; apical lobe small, not extending to level of apex of lateral lobes.

#### EXPLANATION OF PLATE II

Penes of *Ypirangathemis* and *Uracis*; in each figure the upper drawing is a ventral view, and the lower drawing is a lateral view drawn from the right side (with the ventral edge at the top of the drawing). All are drawn at the same magnification, with projection apparatus; magnification about 34X.

FIG. 6. *Y. calverti*, No. 2, São Bernardo, São Paulo, Brazil, 25 January 1933 (Coll. E. Schmidt). FIG. 7. *U. siemensi* Kirby, No. 1, Belem, Para, Brazil, 5 August 1922, J. H. Williamson and J. W. Strohm (Coll. Museum of Zoology). FIG. 8. *U. fastigiata* (Burmeister), No. 1, Rio Jatun Yacu, Oriente, Ecuador, March 1936, W. C. Macintyre (Coll. C. H. Kennedy). FIG. 9. *U. imbuta* (Burmeister), No. 2, Punta Gordas, British Honduras, June 1933, J. J. White (Coll. Museum of Zoology). FIG. 10. *U. infumata* (Rambur), Porto Velho, Amazonas, Brazil, 19 May 1922, J. H. Williamson and J. W. Strohm (Coll. Museum of Zoology).

Legend: A—apical lobe; I—internal lobes; L—lateral lobes; M—medial lobes; MP—median process; P—posterior lobe.





*Female Genitalia* (fig. 2). The most striking character of *Y. calverti*, and the character which gives the leading clue to the relationships of the genus, is the structure of the terminal abdominal segments of the female. In the structure of the ninth sternite of the female, *Ypirangathemis* is strikingly like *Uracis* (cf. figs. 1 and 2), the only other libelluline genus known to the writer in which this character appears. Several libellulines have a narrow and greatly elongate vulvar lamina, but do not have this peculiar blade-like elongation of the ninth sternite.

*Measurements* (in mm.). Male: hind wing 19.5–22.0 (average of 14 ♂, 21.1); abdomen 17.0–18.5 (average of 9 ♂, 17.8); stigma 3.0–3.8 (average of 16 ♂, 3.4). Female: hind wing 21.0–23.0 (average of 5 ♀, 21.8); abdomen 16.5–18.0 (average of 4 ♀, 17.1); stigma 3.3–3.7 (average of 5 ♀, 3.5).

*Material Examined*. BRAZIL: 13 ♂ and 5 ♀, São Bernardo, São Paulo, 25 January 1933, Fritz Wagner (collection of E. Schmidt); 3 ♂, São Paulo (no date or collector, in collection of Zoologisches Museum, Berlin). Allotype female, No. 3a, São Bernardo, São Paulo, 25 January 1933. The allotype female will be deposited in the collection of Dr. P. P. Calvert of Cheyney, Pa.

#### THE SYSTEMATIC POSITION OF THE GENUS YPIRANGATHEMIS

On the basis of wing venation and other external characters, most specimens of *Ypirangathemis calverti* will key out (Borror, 1945) to the genus *Erythrodiplax*, hence *Ypirangathemis* must be closely related to *Erythrodiplax*. On the basis of the structure of the female genitalia, *Y. calverti* is certainly very closely related to *Uracis*. On the basis of penis structure, *Y. calverti* is fairly closely related to both *Erythrodiplax* and *Uracis*, but not very closely related to *Tarnetrum* or other genera.

In penis structure *Y. calverti* resembles Groups 2–4 of *Erythrodiplax* (Borror, 1942) in the possession of well developed and erectile internal lobes. It differs from these species, however, in having a much smaller median process, and in having an additional lobe (fig. 6, P) arising from the median process. On the basis of wing venation, *Y. calverti* might well be placed in the genus *Erythrodiplax*. No species of *Erythrodiplax* have the ninth sternite of the female of the structure found in *Y. calverti*, though a few species (notably *E. hyalina* Förster and *E. juliana* Ris) have fairly elongate vulvar lamina.

The penes of four species of *Uracis* which the writer has been able to study are illustrated in figs. 7–10. On the basis of these species, the penis in *Uracis* is characterized by (1) a well developed apical lobe, which extends as far distad as the lateral lobes or farther; (2) small lateral lobes which are more or less rounded apically; (3) a large and well developed median process which is sometimes (*siemensi*, and to a lesser extent *fastigiata* and *infumata*) bilobed apically, and which bears one (*infumata*) or two (*imbuta*, *fastigiata*, and *siemensi*) pairs of erectile, sac-like, and laterally located internal lobes; in *siemensi* the median process also bears a pair of spine-like processes located dorso-laterally, and an erectile sac-like posterior lobe located on its dorsal side; and (4) the medial lobes are small.

In penis structure, *Ypirangathemis* and *Uracis* are somewhat sim-

ilar, but differ in a few respects. In *Ypirangathemis* the median process is much smaller, the apical lobe is smaller, and the lateral lobes are relatively larger and have their apices drawn out ventrad.

In wing venation *Ypirangathemis* and *Uracis* are similar in that both have the sectors of the arculus stalked, the last antenodal in the front wing is usually incomplete, and the principal longitudinal veins are similar. These two genera differ in the position of the arculus (usually farther distad in *Uracis*) and in the number of cubito-anal crossveins (usually one in *Ypirangathemis*, usually 2-6 in *Uracis*; in some other venational characters the differences are quantitative rather than qualitative; the supratriangle is free in *Ypirangathemis* but is sometimes crossed in *Uracis*, the triangle in the hind wing is more often crossed in *Uracis* than in *Ypirangathemis*, and CuP (Cu<sub>1</sub>), which arises at the anal angle of the triangle in *Uracis*, is sometimes separated from the angle of the triangle in *Ypirangathemis*.

The most striking similarity between *Ypirangathemis* and *Uracis* is in the structure of the terminal abdominal segments of the female. Both have the vulvar lamina elongate and extending beyond the apex of the abdomen, and both have the sternite of the ninth segment drawn out into two approximated processes which extend caudad to the apex of the vulvar lamina. This elongation of the vulvar lamina appears in a few other libellulines (e. g., *Sympetrum cordulegaster*, *S. parvulus*, and possibly others), but as far as this writer is aware no other libellulines have sternite of the ninth segment of the structure found in *Uracis* and *Ypirangathemis*.

The differences between *Ypirangathemis* and *Sympetrum-Tarnetrum*<sup>1</sup> appear such as to preclude the possibility of a very close relationship between them. The principal differences are in a few venational characters, the structure of the posterior lobe of the prothorax, and in the structure of the penis. The principal difference in wing venation lies in the position of the arculus—a fairly basic character; in *Sympetrum-Tarnetrum* the arculus is between the first and second antenodals, and is usually closer to the first, while in *Ypirangathemis* it is closer to the second, and is often opposite or distal to the second antenodal. The posterior lobe of the prothorax in *Sympetrum-Tarnetrum* is erect, narrowed basally and more or less bilobed distally, and bears at its apex a fringe of long hairs; in *Ypirangathemis* the prothoracic lobe is quadrately rounded, and not narrowed basally or bilobed distally.

The penis in *Sympetrum-Tarnetrum* is characterized by the following: (1) the terminal segment is short and stout; (2) the apical lobe is large and sac-like, and often extends distad as far as the other lobes or farther; (3) there is no posterior lobe; (4) the median process<sup>2</sup> is reduced to a heavily sclerotized, slender or flattened, forked process that often

<sup>1</sup>The writer has studied the penes of 17 species of *Sympetrum* and *Tarnetrum*, including *T. illotum* (Hagen) (the type of *Tarnetrum*), *T. corruptum* (Hagen), and *S. vulgatum* (Linnaeus) (the type of *Sympetrum*). These 17 species fall into several fairly well defined groups on the basis of penis structure; the *Tarnetrum* group (*corruptum*, *illotum* and its varieties, and *nigrocreatum* Calvert) is no more distinct a group than any of the others. In this paper the species in these two genera are considered as a single complex, *Sympetrum-Tarnetrum*.

<sup>2</sup>Called the "cornua" by Kennedy (1922) and Bartenef (1915).

extends beyond the other lobes; and (5) there is a pair of internal lobes, which are sometimes large and extend beyond the apex of the lateral lobes.

The penis of *Ypirangathemis* differs from that of *Sympetrum-Tarnetrum* in having a much smaller apical lobe that is not sac-like, in having a posterior lobe, and the median process is small and quite unlike that of *Sympetrum-Tarnetrum*. These differences may be seen by comparing fig. 6 with the figures of Plate III; each of the species illustrated in Plate III represents a different group of the *Sympetrum-Tarnetrum* complex.

On the basis of penis structure, female genitalia, wing venation, and other characters, it appears that *Ypirangathemis* is closely related to both *Erythrodiplax* and *Uracis*. In most classifications of the Libellulidae (e. g., those of Ris, Tillyard, Needham, etc.) *Erythrodiplax* and *Uracis* are placed in different groups or tribes; this position of *Ypirangathemis* suggests that our present concept of the intergeneric relationships in the Libellulidae is rather incomplete.

#### RECOGNITION OF YPIRANGATHEMIS

In the writer's key to the New World genera of the Libellulidae (1945), most specimens of *Y. calverti* would run out to *Erythrodiplax* at couplet 77'; a few specimens would run out to *Erythrodiplax* at couplets 99' and 110', and a few would run to couplet 82 (which leads to *Uracis*, *Erythrodiplax*, and *Dythemis*).

Females of *Ypirangathemis* can be separated from *Erythrodiplax* by the structure of the vulvar lamina and the sternite of segment 9; the males of most species of *Erythrodiplax* do not have the wing spots characteristic of *Y. calverti*. Of the species of *Erythrodiplax* which might have wing spots like those in *Y. calverti*, only *E. umbrata* (L.) occurs in southern Brazil, and it differs from *Y. calverti* in being larger and in having two cell rows between IR<sub>2</sub> and Rspl (only one row in *calverti*).

*Ypirangathemis* can be most readily separated from *Uracis* by certain venational characters: triangle in the hind wing opposite the arculus (distal to the arculus in *Uracis*), usually only one cubito-anal crossvein in the hind wing (usually 2-6 in *Uracis*), and the supra-triangle is free (often crossed in *Uracis*).

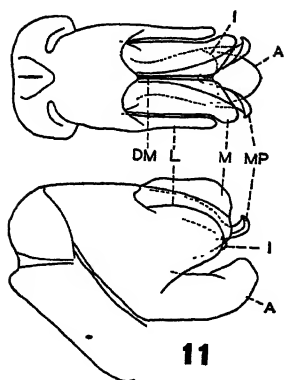
To fit *Ypirangathemis* into the writer's key (1945), couplets 82' and 83 would have to be rewritten, and a new couplet added to separate

#### EXPLANATION OF PLATE III

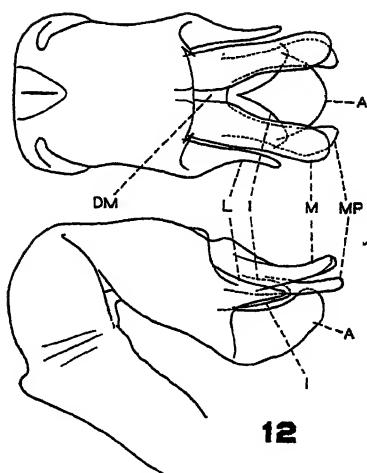
Penes of *Sympetrum* and *Tarnetrum*, ventral and lateral views (as in Plate II). All are drawn to the same magnification, with projection apparatus; magnification about 34X.

FIG. 11. *T. corruptum* (Hagen), Dubois Idaho. FIG. 12. *T. illotum illotum* (Hagen), Claremont, Calif. FIG. 13. *S. vulgatum* (L.), Berlin, Germany. FIG. 14. *S. vicinum* (Hagen), Franklin Co., Ohio. FIG. 15. *S. obstrusum* (Hagen), East Randolph, New York. FIG. 16. *S. semicinctum* (Say), Powhatan Point, Ohio. All specimens in the writer's collection.

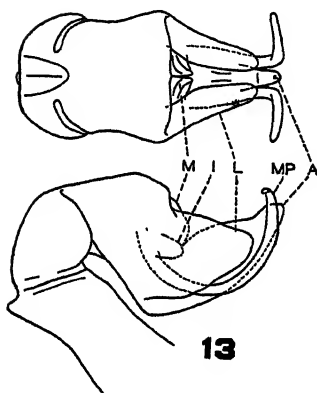
Legend: A—apical lobe; I—internal lobes; L—lateral lobes; M—medial lobes; MP—median process; P—posterior lobe.



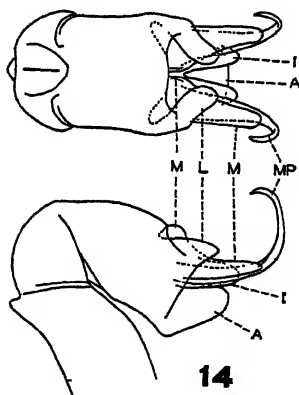
11



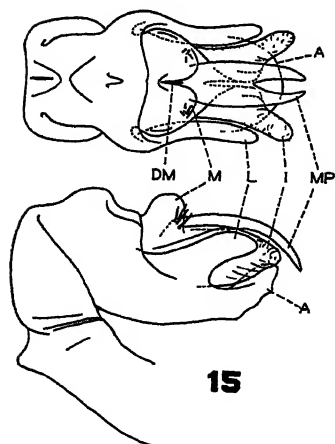
12



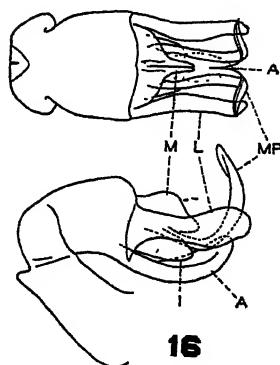
13



14



15



16

*Erythrodiplax* from *Ypirangathemis*; this new couplet, No. 118, would be reached from couplets 77', 83, 99', and 110'. These changes and additions are as follows:

- 82'. Base of triangle in hind wing opposite arculus; wing tips hyaline; vulvar lamina variable. . . . . 83
- 83 (82'). Hamules 2-parted (fig. 66); vulvar lamina one-fourth as long as segment 9, or longer. . . . . 118
- 83'. Hamules not 2-parted (fig. 62); vulvar lamina poorly developed, little more than a bilobed thickening of the caudal margin of the eighth sternite, and not projecting ventrad (fig. 68). . . . . *Dythemis*
- 118 (77', 83, 99', 110'). Female with vulvar lamina extending well beyond apex of abdomen, and sternite of segment 9 drawn out into two closely approximated processes which extend as far caudad as apex of vulvar lamina; males and most females with a large brownish black spot in each wing which extends the width of the wing between second postnodal and proximal end of stigma; 1 cell row between IR<sub>3</sub> and Rspl; hind wing 19.5-23.0 mm.; southern Brazil. . . . . *Ypirangathemis*
- 118'. Female with vulvar lamina usually not extending beyond tip of abdomen, often shorter than segment 9, and ninth sternite of female normal, not as above; if from southern Brazil and wings are colored as above, then hind wing is 25.5-33.5 mm., and there are 2 cell rows between IR<sub>3</sub> and Rspl. . . . . *Erythrodiplax*

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1945. A key to the New World genera of Libellulidae (Odonata). Ann. Ent. Soc. Amer., 38 (2): 168-194; 72 figs.
- Kennedy, Clarence H. 1922. The morphology of the penis in the genus *Libellula* (Odonata). Ent. News, 33 (2): 33-40; pl. II-III.
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#### EIGHTH INTERNATIONAL CONGRESS

The Eighth International Congress of Entomology will be held in Stockholm, Sweden, August 8-16, 1948. The fact that all steamship sailings are currently booked to capacity for months in advance makes it seem necessary for those expecting to attend the congress in 1948 to arrange for passage as early as possible. Steamship companies have not issued sailing lists for 1948, but expect to do so in the early fall. A number of lines have listed sailings for the present season, among them, the Cunard, French, Belgian, Swedish, Norwegian, Gdynia (Polish), Holland-American, etc., the first mentioned expecting soon to have two new steamers in service. It is understood that the Thirteenth International Congress of Zoology will be held in Paris some time in July, 1948, and it is hoped that all entomologists going to Stockholm will plan to attend the Zoological Congress also in order that the interests of the entomologists may be fully represented before the more comprehensive body. Should a sufficient number of individuals indicate that they expect to sail about mid-June, it may be feasible to engage passage on the same steamer. Early information as to the probable number of participants is especially desired in order that the housing committee in Stockholm may make the necessary arrangements. The undersigned, as member of the executive committee, would appreciate it if he be kept informed as early as possible as to plans of those expecting to attend the sessions.

O. A. JOHANSEN,

Comstock Hall, C. U., Ithaca, N. Y.

June, 1947.

## THE GENUS MESAMIA IN MEXICO (Homoptera: Cicadellidae)

DWIGHT M. DELONG AND RUTH V. HERSHBERGER,<sup>1</sup>

Ohio State University

The Genus *Mesamia* was erected by Ball in 1907<sup>2</sup> as a subgenus of *Eutettix* to include a group of species with flattened vertex, the margin of which is acutely angled with the front.

The elytra contain a second cross nervure and a constricted second antepical cell. There are many supernumerary veinlets along the clavus and costa.

*Mesamia nigradorsum* Ball was designated as the genotype. Fifteen species placed in this genus have been described from the United States and one species, *orizaba* Ball, was previously described from Mexico. The Mexican species was described from a pair of specimens, the female of which was designated as the holotype. Collections made by the authors and their co-workers during the past few years have furnished an abundance of material which reveals the fact that these two specimens belong to different but closely related species. Dr. Oman of the U. S. National Museum has examined these two series of specimens and verified this conclusion. As a result of this decision, the allotype male of *Mesamia orizaba* is described at this time and the species to which the allotype of *orizaba*, as described by Ball, belongs is the species described here as *bifurcata*. In addition six other new species and one variety are described at this time.

### *Mesamia orizaba* Ball

*Mesamia orizaba* Ball, Bull. Brooklyn Ent. Soc. 26: 92, 1931.

Resembling *prescottia* in form and general appearance but smaller and with more obtusely angled vertex. Length, 5 mm.

Vertex produced, with rounded apex, about one-third wider between eyes at base than median length.

*Color*: Vertex pale brownish, margin ivory white with a narrow marginal black line just above and another just below, a narrow ivory wedge-shaped spot extending back from margin to disc and interrupting the black line at middle. Pronotum dark brown. Scutellum orange brown with a pair of ivory dashes near middle of base and a pair of ivory spots on lateral margins. Elytra pale brownish, subhyaline; nervures dark brown; apical margin and spots in apical cells brown with three pairs of ivory spots along commissure. Face light brown with pale arcs.

*Genitalia*: Female last ventral segment with posterior margin roundedly produced to middle, slightly indented either side of median spatulate process which is short but produced beyond the margin of segment. Spatulate process slightly indented at middle. Male plates

<sup>1</sup>The authors wish to acknowledge with appreciation the assistance obtained from a Grant-in-Aid from the Sigma Xi research fund.

<sup>2</sup>Dav. Acad. Nat. Sci. 12: 31, 1907.

long, gradually tapered from a broad base to acutely pointed apices. Styles broad at base, gradually tapered to pointed apices. The apical half of style is quite slender. The aedeagus in lateral view is conversely rounded on dorsal margin near base, just beyond which is a pair of lateral spines directed dorsally. The apical half of aedeagus is divided forming a pair of long slender parallel processes. The pygofer bears a single spine on the caudal ventral margin.

The *holotype* female was collected at Orizaba, Vera, Mexico. *Allotype* male as here described collected at Tuxpan, Mich., October 5, 1941, by Good, Caldwell, Plummer and DeLong.

Specimens are also at hand from Zacapu, Mich., October 4, 1941, Buena Vista, Gro., October 23, 1941 (K 340, elev 3400), Cuernavaca, Mor. September 8, 1939 (elev 7000), Puebla, Pue., October 18, 1941 (elev 8500), Chilpancingo, Gro., October 25, 1941 (elev 4700), Iguala, Gro., October 25, 1941 (elev 3600), and Tepoztlan, Mor., September 11, 1941 (elev 6000) by Caldwell, Good, Plummer and DeLong. Also *paratype* male from Tlalpam, D. F., September 16, 1923, collected by Dr. A. Dampf. Compared with type male and female specimens have been placed in the U. S. National Museum.

*Paratypes* also from Zitacuara, Mich., (6800 ft.), September 28, 1945, by Plummer, Elliott, Hershberger, DeLong, Zimapan, Hidalgo, K 222 (6800 ft.), October 31, 1945, by DeLong, Hershberger, Elliott.

#### *Mesamia bifurcata* n. sp.

Resembling *orizaba* in general form and appearance but with a bifurcate spine on the pygofer of male. Length 5-6 mm.

Vertex produced and bluntly angled, about one-fourth wider between eyes at base than median length.

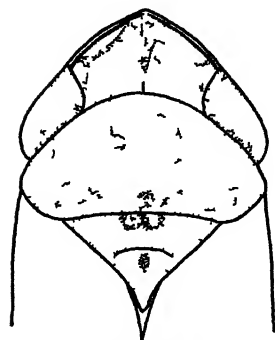
*Color*—Pale brownish marked with dark brown and black. Vertex with a dark brown line just above margin which is slightly broken at the middle by a median white mark. Pronotum with anterior portion light brown, the disc and posterior portion dark brown. Scutellum reddish brown. Elytra pale brownish subhyaline, nervures dark brown, costal veinlets heavily embrowned. Face rather dark brown with pale arcs, a dark brown marginal line just beneath white vertex margin.

*Genitalia*—Female last ventral segment with posterior margin angularly excavated either side of a narrow, rather short median spatulate process which is slightly notched at apex. Male valve short and rounded, plates rather long, broad at base rather rapidly narrowed to acutely angled apices. Styles elongate and rather gradually narrowed to pointed apices. Aedeagus in lateral view erect, the apical half divided forming two long rather slender processes which are directed anteriorly and dorsally. The apical spine on the pygofer is bifid.

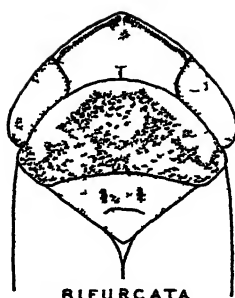
*Holotype* male collected at Tasquillo, Hgo., October 29, 1941, K 172 (elev 5600 ft.) by E. E. Good and D. M. DeLong. *Allotype* female collected at Zimapan, Hgo. (17 miles N.) September 26, 1941, by Good.

#### EXPLANATION OF PLATE I

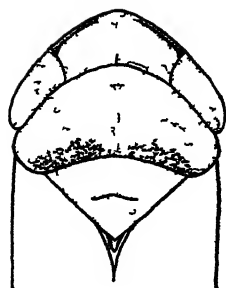
Dorsal view of heads and ventral view of last ventral segment of female abdomen of species of *Mesamia* as labeled.



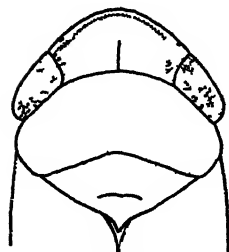
ORIZABA



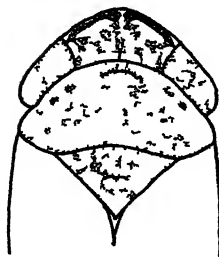
**BIFURCATA**



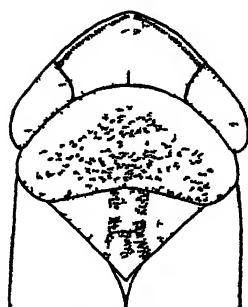
ALTA



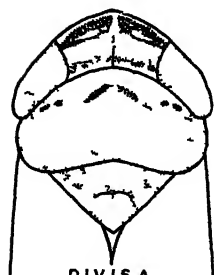
**PUEBLA**



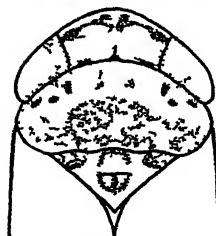
## INTERRUPTA



**MONTANA**



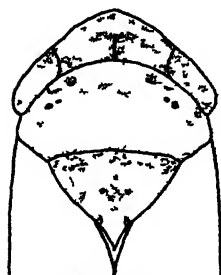
DIVISA



**SEPARATA**



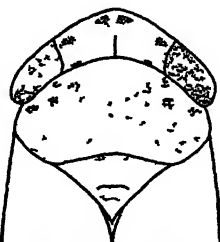
**PUEBLA**



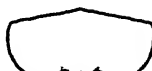
FRIGIDA



ORIZABA



QUADRIPUNCTA



**MONTANA**



**SEPARATA**



**BIFURCATA**



**ALTA**



**DIVISA**



and DeLong. *Paratype* males and females collected at Zimapan, Hgo., Carapan, Mich., October 2, 1941 (K. 432; elev. 7500); Zacapu, Mich., October 4, 1941; Toluca, D. F., September 29, 1941 (K. 97; elev. 9700); Puebla, Pue., October 18, 1941 (K. 78; elev. 8500) and Mexico City, D. F., 18 kms. west on Toluca Rd., September 1, 1939 (elev. 8500 ft.) by DeLong, Plummer, Caldwell and Good. Male *paratypes* collected at Rio Frio, D. F. (K. 65), October 10, 1945, by DeLong, Hershberger and Elliott; female *paratypes* collected at Mil Cumbres, Mich., September 30, 1945, by Plummer, DeLong, Hershberger and Elliott. *Paratypes* at Tasquilla, Hidg. (K. 174; elev. 6000) October 30, 1945; Mexico City D. F., October 22, 1945, by DeLong, Hershberger, Elliott; also Rio Frio, D. F. (K. 65), October 10, 1945, by same collectors; Mexico, Mich. State Border (K. 139; 9200 ft.), September 28, 1945, Hidalgo, Mich., September 29, 1945, Morelia, Mich., September 30, 1945, Laguna de Zempoala, Mor., October 21, 1945, by Plummer, DeLong, Hershberger and Elliott; Cuernavaca, Mor., September 25, 1945, by Balock, DeLong, Hershberger and Elliott; Jalapa Rd. (K. 341), October 14, 1945, by Shaw, DeLong, Hershberger, Elliott; Tepoztlan, Mor., 1943, by Plummer.

The specimen labeled allotype male of *orizaba* in the Ball collection, U. S. Nat. Mus. is made a paratype of this species and is labeled "Orizaba, H. S. and F. D. G., Dec., 1887." A paratype female has also been placed in the U. S. Nat. Mus. collection.

### *Mesamia alta* n. sp.

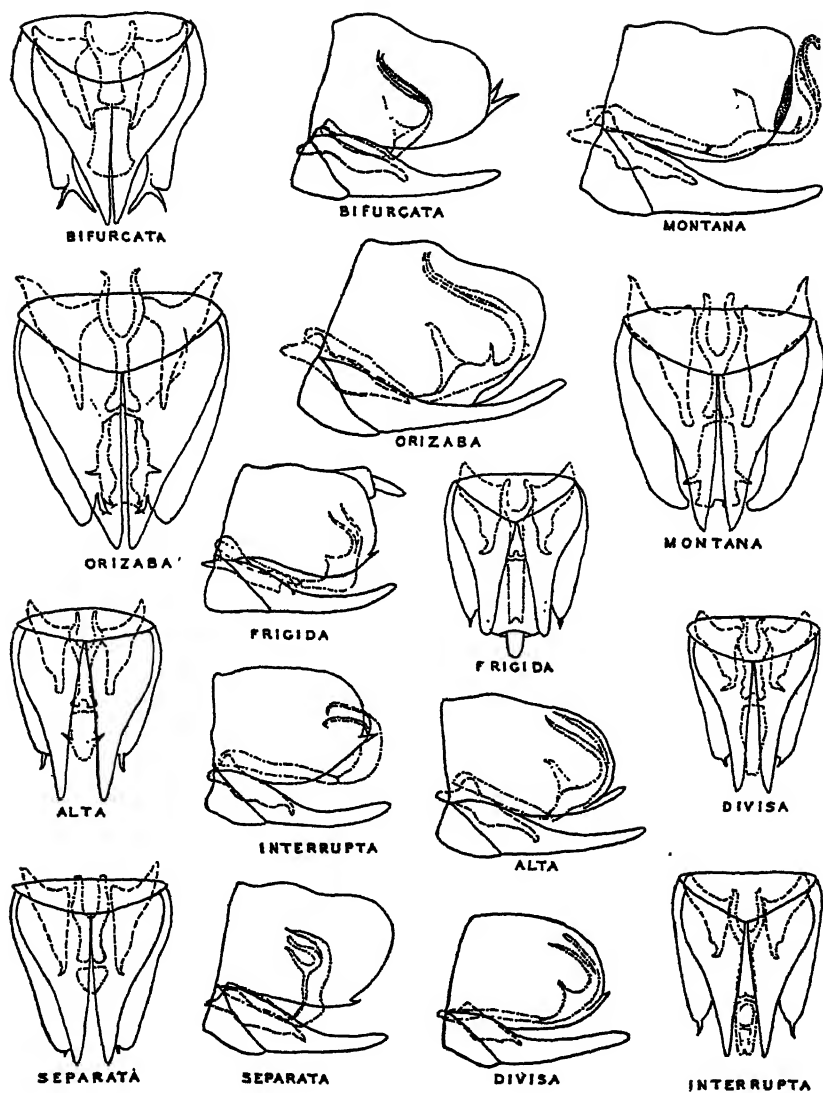
Resembling *diana* and *prescottia* in form and general appearance but with distinct male genitalia. Length 4.5 to 5 mm.

Vertex produced and rounded, more than one-third wider between eyes at base than median length.

*Color*: Vertex pale brownish with a dark brown narrow marginal band just above margin which is interrupted at middle. Pronotum dark brown, paler along anterior margin. Scutellum dark reddish brown, a white spot at about the middle on each posterior margin joined with a narrow white longitudinal line which crosses scutellum. Elytra with anterior half subhyaline, the claval area dark brownish, veins brown. Face brownish with paler arcs; a narrow dark brown band just beneath margin.

*Genitalia*: Female last ventral segment with the posterior margin produced and bluntly rounded, sloping either side to, and notched either side of, a median tooth which is short, broad and slightly notched at apex. Male plates rather narrow, elongate, apices slender and bluntly pointed. Styles rather short, rapidly narrowed from a broad base to a narrow blunt apex. Aedeagus rather broad at base, narrowed at about one-third its length and divided forming a pair of long slender parallel apical processes which are curved anteriorly and dorsally. A pair of short lateral spines protrude at about one-third its length. The pygofer spine is on the ventral apical margin and is single.

*Holotype* male collected at Tuxpan, Mich., October 5, 1941 (K. 186; elev. 7600). *Allotype* female collected at Puebla, Pue., October 18, 1941, by Caldwell, Good, Plummer and DeLong. *Paratype* males collected at Iguala, Gro., September 11, 1939, by Plummer and DeLong.



Ventral and lateral views of male genital structures of species of *Mesamia* as labeled.

*Mesamia montana* n. sp.

Resembling *prescottia* in form and general appearance but with distinct male genitalia. Length 5.5 to 6 mm.

Vertex produced and blunt, scarcely angled, about one-third wider between eyes at base than median length.

*Color*: Vertex pale brownish yellow, margin yellow with a narrow dark brown line just above margin which is interrupted by a narrow elongate yellow spot at apex and a rather broad paler area bordering the brown margined line. Pronotum dark brown with paler markings on anterior portion. Scutellum reddish brown with a pale longitudinal line on either side at about one-third the width, extending across scutellum. Elytra pale brownish, subhyaline with dark brown nervures. Face with a narrow dark brown band just beneath margin and with pale arcs on a darker brownish background.

*Genitalia*: Female last ventral segment with posterior margin broadly, slightly excavated with a short, broad, median spatulate tooth, which is deeply notched at middle. Male plates long, rapidly narrowed to acutely pointed apices. Style broad at base, gradually narrowed to rather narrow blunt apices. Aedeagus in lateral view narrow and elongate, bearing a pair of lateral spines at about half its length. The apical half of aedeagus bifid forming a pair of long slender processes which are recurved. The caudal apical spine is about the middle of the pygofer and single.

*Holotype* male, *allotype* female and male and female *paratypes* collected at Urapan, Mich., from shrubs October 1, 1941, by Plummer, Good, Caldwell and DeLong. Male and female *paratypes* collected at Zitacuaro, Mich., from shrubs September 29, 1941 (K. 160; elev. 7500) by the same collectors.

*Mesamia divisa* n. sp.

Resembling *tarbella* in general form and appearance but with distinct male genitalia. Length 4.5 to 5 mm.

Vertex rather short, roundedly produced, more than one-third wider between eyes at base than median length.

*Color*: Vertex pale brown with a conspicuous black band just above margin of vertex which is interrupted at middle and broadened on either side of the pale median spot, and next each eye. A paler spot is just posterior to the band at about the middle on either side and in the concavity of the narrowed portion of the dark band. Pronotum with the anterior third pale brown, the posterior two-thirds darker brown; a row of two or three dark brown spots just posterior to each eye on anterior portion of pronotum. Scutellum pale brown. Elytra pale, subhyaline, veins dark brown. Face pale brownish with paler arcs on each side and an interrupted dark brown line just beneath margin of vertex.

*Genitalia*: Female last ventral segment produced on lateral angles, between which the posterior margin slopes anteriorly to middle where it is notched either side of a short, broad, median, sunken tooth. Male plates elongate, narrow, concavely rounded to bluntly pointed apices. Style narrow from broad base to apex which is concavely notched on outer margin just before the pointed, outwardly directed apical finger-

like process. The aedeagus is pointedly produced on the dorsal margin near the base. The apical half is divided into a pair of long slender, parallel processes which are directed dorsally and anteriorly. The pygofer spine is single and located on the ventral caudal margin.

*Holotype* male collected at Iguala, Gro., September 11, 1939. *Allotype* female from Orizaba, Vera., October 17, 1941 (K. 280) by Good, Plummer, Caldwell and DeLong. *Paratype* males and females from the same localities and from Tuxpan, Mich., October 5, 1941 (K. 186; elev. 7600); Tasquillo, Hgo., October 29, 1941 (K. 172; elev. 5600); and Chilpancingo, Gro., October 25, 1941 (elev. 4700) by Good and DeLong. *Paratypes* from Rio Tuxpan, Mich., September 29, 1945, by Plummer, DeLong, Hershberger, Elliott.

### *Mesamia interrupta* n. sp.

Resembling *coloradensis* and *divisa* in form and general appearance but with distinct male genitalia. Length of male 4.5 mm.

Vertex roundedly produced, more than one-third wider between eyes at base than median length.

*Color*: Vertex pale brownish with a dark brown band just above margin broadened either side of a narrow median pale interruption. There is a pale elongate spot either side just posterior to and in the concavity of the black marginal band. Pronotum dark brown with small dark brown spots just posterior to each eye. Scutellum brown tinged with orange, a pale linear longitudinal spot extending across scutellum about one-third the distance from each side at base. Elytra pale subhyaline with brownish mottlings, veins dark brown. Face brownish with paler arcs. A narrow dark brown transverse line just beneath margin interrupted at middle.

*Genitalia*: Male plates elongate, rapidly narrowed to pointed apices. Style broad at base, short, rapidly narrowed to a bluntly pointed apex which is concavely indented on outer margin. Connective longer than aedeagus. The basal portion of the aedeagus is broad, the apical half is divided into two very slender processes which are not proximal. The pygofer spine is short, and protrudes caudally on the caudal margin of aedeagus.

*Holotype* male and *paratype* males collected at Mexico City, D. F., September 13, 1939, by D. M. DeLong (elev. 7500 ft.).

### *Mesamia separata* n. sp.

Resembling *coloradensis* in general form and appearance but with distinct male genitalia. Length 4.5 mm.

Vertex rather short and broadly rounded, in the female appearing almost parallel margined. Almost twice as wide between eyes at base as median length.

*Color*: Vertex pale brown, paler anteriorly with four black elongated spots forming a broken band just above margin. There is a transverse black spot next each eye and a pair of proximal triangular spots at apex with the broadened bases of the spots narrowly separated. Pronotum dark brown, anterior portion paler with three dark brown spots just back of each eye. Scutellum pale with basal angles reddish brown. Elytra pale subhyaline with dark brown veins and dark brown mottling.

Face dull brown with paler arcs and a narrow dark brown transverse band just beneath margin of vertex.

*Genitalia*: Female last ventral segment with prominent produced angles between which the posterior margin is broadly notched either side of a short broad median tooth which is produced to the apex of the lateral angles. Male plates concavely narrowed on apical half to form bluntly pointed apices. The styles are elongate and wedge-shaped, gradually narrowed to pointed apices which are curved slightly outwardly at the tip. The aedeagus is rather broad in lateral view and erect. The apical third is divided into three rather distinctly divided processes which are directed anteriorly.

*Holotype* male and *allotype* female collected at Orizaba, Vera., October 17, 1941 (K. 280) by Plummer, Good, Caldwell and DeLong. *Paratype* females collected at Tehuacan, Pue., October 17, 1941, by Caldwell, Plummer, Good and DeLong. Paratypes from Tasquilla, Hidg. (K. 174; 6000 ft.), October 30, 1945, by DeLong, Hershberger, Elliott. Male and female *paratypes* collected at K-187 on the Guadalajara Road, November 27, 1943, by W. E. Stone.

*Mesamia separata* var. *quadripuncta* n. var.

Resembling *separata* in general form and appearance but with different coloration. Length 4 mm.

Vertex broad, scarcely produced, broadly rounded, more than twice as wide between eyes at base as median length.

*Color*: Vertex pale with a small black triangular spot next each eye and a similar spot either side of middle just above margin. Disc infuscated. Pronotum pale with disc darker, a row of three dark spots just back of eye on anterior margin. Scutellum paler. Elytra whitish hyaline, veins dark brown, clavus rather heavily infuscated. Face brownish with pale arcs and a dark brown line just beneath margin.

*Genitalia*: Female last ventral segment similar to *separata* with the posterior margin notched either side of the short median spatulate process.

*Holotype* female collected at Iguala, Gro., Mexico, September 11, 1939, by Plummer and DeLong.

When more material is available this will probably prove to be a distinct species.

*Mesamia puebla* n. sp.

Resembling *orizaba* in general form but with vertex more blunt and rounded, without distinct color markings and with female segment narrowly notched. Length 5 mm.

Vertex blunt, rather broadly rounded almost half as long at middle as basal width between the eyes.

*Color*: Dark gray, vertex unmarked except a very faint brownish line just above margin. Pronotum darker on disc, a few dark markings on anterior margin just back of eyes. Scutellum dark gray; basal angles of scutellum tinted with orange. Elytra gray, subhyaline, veins pale brown without markings; some of cross veins are pale in color. Face pale brown, infuscated above, with a pale narrow brown line just

beneath vertex margin. Abdomen yellow. Female last ventral segment black.

*Genitalia*: Female last ventral segment with produced lateral angles, the posterior margin rather narrowly notched, either side of a rather broad, rounded median tooth.

*Holotype* female collected at Puebla, Pue., Mexico, October 18, 1941, by Caldwell, Plummer, Good and DeLong.

Although only a single female specimen represents this species it is so unique in color and form it seems proper to describe in it this group.

*Mesamia frigida* n. sp.

Related to *divisa* by the characters of the male genitalia but with different appearance and coloration and with vertex more angularly produced. Length, male 5 mm.

Vertex bluntly angularly produced, about twice as wide between eyes at base as median length.

*Color*: Vertex appearing brownish, the anterior half dark brown blending into the marginal black line. Five light areas are produced, one at middle, one each side about half way between middle and eyes, just back of marginal line, and one next each eye. The posterior half pale brown, mottled. Pronotum dark brown mottled. A pale spot back of each eye containing three small dark brown spots. Scutellum dark with paler spots. Elytra appearing quite dark brownish, due to the heavy pigment lines and numerous supernumerary veinlets on the claval area especially. The corium and costal portions are paler with dark brownish veins. Face dark brown with pale arcs, a black transverse marginal line just beneath vertex margin.

*Genitalia*: Male plates rather long, remaining rather broad to tips which are blunt and rounded. Styles triangular, rather broad at base, tapered to finger-like apices. Aedeagus in lateral view right angled in shape, broadest at middle, with three long apical processes, the central one of which is largest. These curve anteriorly and are produced dorsally. The pygofer spine is short and at the base of the apical portion.

Described from a single male collected at Rio Frio (K. 65; 10,000 ft. elevation), October 10, 1945, by DeLong, Hershberger and Elliott.

NOTES D'ENTOMOLOGIE CHINOISE.—This serial and the following one are not well known in the U. S. They are published by the Musée Heude, Université l'Aurore, Avenue Dubail, Shanghai, China. The 'Notes' has already completed its tenth volume, having commenced in 1929. Each volume consists of a number of papers, appearing separately. The volumes have carried from three to 14 articles and 85 to 486 pages each. Eight numbers were published in 1942 and 1943, and publication is expected to resume shortly. The articles are mostly written in French or English, and deal with insects from China and Indo-China. Most of the papers are taxonomic and principally concern material in the Musée Heude, which has the best collection of Chinese insects. Four Americans, C. P. Alexander, W. D. Funkhauser, J. L. Gressitt and E. R. Tinkham have published from two to four articles each in this serial. The other authors are European, Chinese and Japanese.—J. L. GRESSITT.

## LAMINOMADA, NEW SUBGENUS OF NOMADA (Hym.: Apoidea)

HUGO G. RODECK,  
University of Colorado Museum

### Subgenus *Laminomada*, new

Type species, *Nomada hesperia* Cockerell 1903, present designation.

Medium-sized (8–11 mm.), vernal (March–June), sexually monomorphic species of rather robust form. The type and only known species possesses the following peculiarities which distinguish it from *Holonomada*, in which it has formerly been included:

Similar in facies to *Holonomada* except size somewhat smaller; sides of propodeum not angulate; second and third cubital cells broad below, *extremely narrowed above* on marginal cell; *anterior femora of male expanded below to form a very broad lamina, deeply concave in front*; *anterior coxae with strong spines*, nearly hidden in tufts of hair in male, *gonostyli (parameres) of male genitalia peculiarly twisted apically*.

### *Nomada* (*Laminomada*) *hesperia* Ckll.

*Nomada* (*Holonomada*) *hesperia* Cockerell, Proc. Acad. Nat. Sci. Phila., 55: 563–4, 1903. "So. Cal.," 2 ♂♂.

*Nomada* (*Holonomada*) *hesperia* Cockerell, Psyche, 17: 98, 1910. Pullman, Wash., May 15 and 23, 1909 (♂♂ ?).

*Nomada* (*Holonomada*) *flavopicta* Swenk, Univ. Nebraska Studies, 12: 84, 1912 (1913). New species, 1 ♀, Pullman, Washington, May 14, 1898.

*Male*.—Length 8–11 mm. Head and thorax strongly, densely, and uniformly punctured except lower face and labrum. Head and thorax with yellow or pale yellow markings as follows: mandibles except tips; labrum; clypeus; broad lateral face-marks ending in an oblique point or obliquely curved truncation about or slightly above level of antennal sockets; a narrow line a short distance under eye. Tubercles usually yellow, but in Oregon and Washington specimens sometimes only yellow-spotted or black.

Mandibles short and stubby, rather straight, edges produced into a thin flange. Hair rather long, white, denser on lower face and beneath head and thorax, somewhat appressed on face. Scutellum moderately protuberant, not strongly bilobed. Antennal segment 3 very slightly if at all longer than 4. Scape yellow in front, black at sides and behind. Segment 3 yellow in front, rest of flagellum pale ferruginous in front, blackened and undulate behind. Tegulae yellow except basally.

Wings uniformly and very slightly infuscated, in Oregon and Washington specimens practically hyaline. Basal vein considerably basad of transverse median (fig. 6). Second cubital cell much narrowed above by obliquity of both first and second transverse cubital veins, receiving first recurrent vein beyond middle of base. Third cubital much narrowed above by the strong curvature of third transverse cubital. Second recurrent strongly angulate, meeting third cubital at about the middle. Hamuli 7–8.

Legs black and yellow. Anterior coxae (fig. 2) with short, conical, pointed, black tubercles, hidden in long, dense, white hair. *Anterior*

*femora very widely expanded into a concavo-convex lamina* (fig. 2); middle femora widely expanded below toward apical end; hind femora strongly arcuate upward on basal half; middle, and particularly hind, basitarsi arcuate. Yellow markings on legs as follows: anterior trochanters except base; anterior femora except a V-shaped black mark on top, with apex at distal end of femur, sometimes divided; anterior tibiae except a line outside; all anterior tarsi except apical segment; middle trochanters except above; front and lower edge of middle femora; middle tibiae except behind; basal two to four middle tarsi; a line on apical three-fourths of front of hind femora; whole front of hind tibiae; hind basitarsi in front. Hind tibiae with a conspicuous tuft of long hair apically within; about a dozen pale bristles without.

Abdomen black with yellow bands, finely and densely punctured. Complete yellow bands on segments 1-6, steeply much narrowed medially on segment 1, broadly narrowed to about one-half the lateral breadth on 2-4, subuniform on 5 and 6. Hair of abdomen moderately dense but very short and fine except at apex. Venter of abdomen with broad yellow bands on all except basal sternite, this sometimes with two arcuate marks or without yellow. Seventh tergite blackish brown, moderately broadly rounded, entire. Genitalia (figs. 3-5).

*Female*.—Much like the male, but with the following differences: Punctures of head and thorax strong and dense except on labrum. Yellow marks on head and thorax like the male, but also a short line over apex of eye; dorsum of prothorax; tubercles; a low anterior pleural spot; separated spots on scutellum; a line on postscutellum; and small spots on all coxae.

Dorsum of prothorax not very prominent, rounded laterally, depressed medially considerably below level of antero-median portion of mesonotum. Mandibles rather short, edges flanged. Hair of head and thorax somewhat golden, not very long or dense. Antennae darkened and slightly undulate behind; flagellum gradually thickened toward tip, terminal segment flat-pointed. Tegulae yellow. Wings very slightly and uniformly darkened. Hamuli 8-9.

Anterior coxae with a short, stout, conical, pointed tubercle. Femora not unusually expanded, hind pair slightly arcuate and obliquely joined to trochanter. Legs yellow except black markings as follows: front of anterior coxal tubercle; a line behind front femora and tibiae, middle and hind tibiae, and inside of hind basitarsi. Apex hind tibiae with about eleven graduated, flattened golden bristles outside.

Abdomen as in male.

*Distribution*.—California, Oregon, Washington (fig. 1).

The female of *hesperia* has not previously been described as such nor an allotype selected. Swenk's type of *flavopicta* is available for designation as allotype, but the specimen is in bad condition (examined 8 May 1942) and moreover is from Washington. Since the male holotype is from "So. Cal." the following description and designation of allotype is presented.

*Allotype*.—Female. Length 9 mm., front wing 6.5 mm. Head and thorax moderately coarsely punctured, punctures dense and uniform. Head and thorax black, with yellow markings as follows: Mandibles except tips; labrum; clypeus; broad lateral facemarks narrowing rapidly to a blunt point about half-way between antennal sockets and top



of eye; a line under eye and narrowly a short distance up posterior orbit; a very short narrow line over top of orbit; dorsum of prothorax; tubercles; low anterior mesopleural spot; large separated scutellar spots; line on postscutellum. There are no propodeal spots and no supra-clypeal yellow. Yellow of clypeus and lateral facemarks separated by a black line half-way down sides of clypeus.

Orbits converging below in face view, face wider than high. Tubercles pointed-protuberant. Mandibles rather short, expanded along both edges into a narrow flange-like lamina which increases apparent breadth of apical half of mandible. Hair white, sparse, short except on scutellum, dorsum of propodeum, and under cheeks. Scutellum moderately protuberant, not strongly bilobed, apices rounded. Antennae moderately long, flagellum somewhat heavy. Scape cylindric, subarcuate, yellow in front, black behind. Antennal segment 3 slightly longer than 4, yellow in front, blackened behind. Segments 4 and following light ferruginous, decreasingly darkened behind toward apex. Tegulae broad, oval-elongate, finely and uniformly punctured, shining yellow.

Wings very uniformly, but slightly, infuscated. Hamuli 8. Basal vein basad of transverse median more than half the length of the latter. *Second cubital cell very much narrowed above* (less than one-fourth of its basal breadth) by the obliquity of first and second transverse cubital veins, receiving first recurrent vein beyond middle of vase. Third cubital much narrowed above (about one-third basal breadth) by strongly angled third transverse cubital, receiving second recurrent about middle of base.

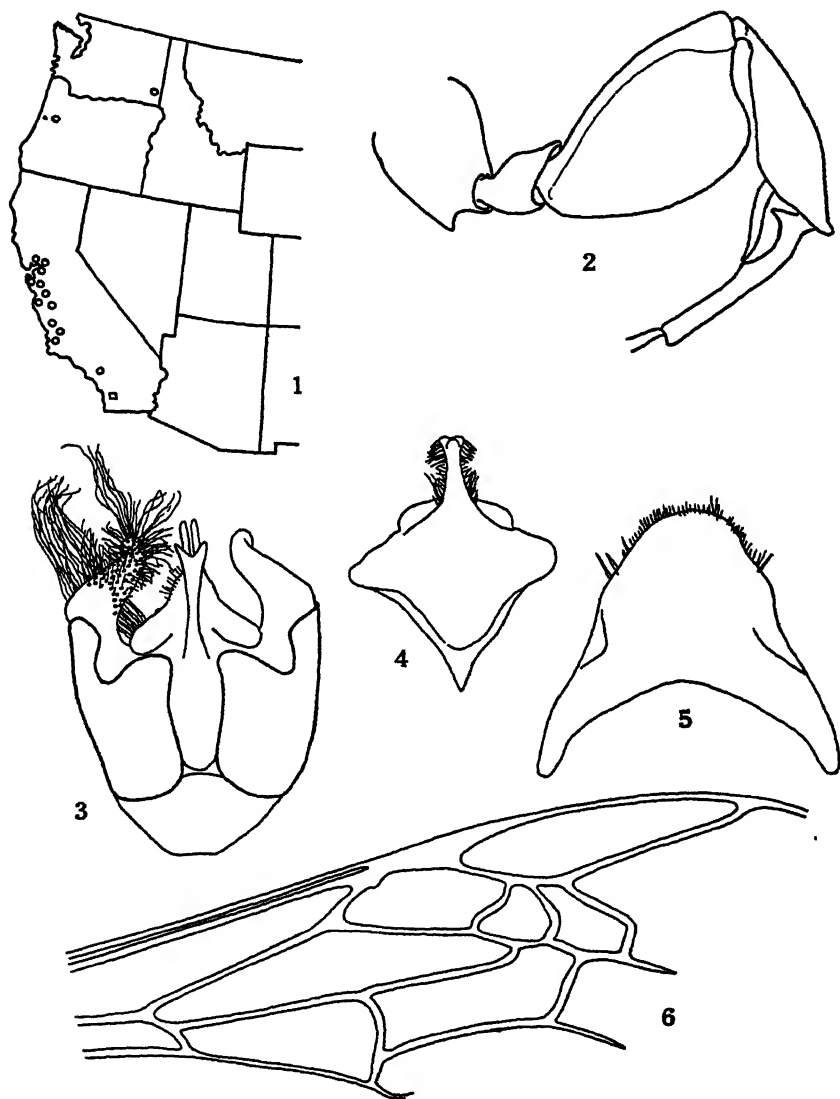
Legs yellow and black. *Anterior coxae with a stout, conical, pointed spine at apex.* Coxae black, with small apical yellow spots, those on anterior coxae involving front of spines. A yellow line on outside of front coxae. Anterior and middle trochanters yellow apically in front, black behind; hind pair black. All femora, tibiae, and tarsi yellow, blackened behind except front and middle tarsi. *Hind femora arcuate*, obliquely attached to trochanters. Apex of hind tibiae with about eleven flattened, golden bristles, graduated in length, intermixed with a few white hairs.

Abdomen black with yellow bands; punctures very dense and uniform, but not deep. Yellow entire bands on all abdominal tergites, somewhat narrowed medially on first three segments. Abdomen nearly hairless, hairs minute. First abdominal sternite with a minute yellow subapical mark on either side sublaterally, remainder of venter nearly all yellow.

Pleyto, Monterey Co., California, 22 May 1920, E. P. Van Duzee collector. From the C. L. Fox Collection, and deposited in the California Academy of Sciences.

SPECIMENS EXAMINED: *California*—1 female, San Ardo, Monterey Co., 23 March 1931, E. P. Van Duzee; 2 males, Salinas, 26 March 1936, E. G. Linsley; 2 males, 4 females, Zion, 4 April 1939, E. G. Linsley; 1 male, Leona Hts., Berkeley Hills, 6 April 1913, J. C. Bridwell; 1 male, Antioch, 11 April 1936, M. A. Cazier; 1 male, Carmel, Monterey Co., 15 April 1919, L. S. Slevin; 1 female, Walnut Cr., Contra Costa Co., 19 April 1913, J. C. Bridwell; 1 female, Lake Elsinore, 21 April 1920, E. P. Van Duzee; 9 females, Mt. Diablo, Contra Costa Co., 28 April

1939, M. A. Cazier; 3 females, Berkeley, 8 May 1912, J. C. Bridwell; 1 female, Pismo, 8 May 1936, on Morning Glory, Isobel McCracken; 2 females, Pleyto, Monterey Co., 22 May 1920, E. P. Van Duzee (Allotype).



*Nomada hesperia* Cockerell

FIG. 1. Distribution of *N. hesperia* Ckll. shown by circles, of *N. h. falconis* n. subsp. by square. 2. Left front leg of male showing coxal spine and expanded femur. 3. Genitalia of male. 4. Ninth ventral segment of male. 5. Eighth ventral segment of male. 6. Venation of fore wing.

*Oregon*—1 male, Corvallis, April 1930, J. Wilcox.

*Washington*—All records from Pullman, as follows: 1 female, 15 April 1907; 1 male, 18 April 1907; 1 female, 19 April 1904; 1 male, 26 April 1904, A. L. Melander; 1 male, 26 April 1907; 1 male, 29 April 1891, A. L. Grant; 1 male, May; 1 male, 1 May; 3 females; 4 May 1901; 1 male, 9 May 1907; 1 male, 13 May 1916; 1 male, 18 May 1906; 1 male, 23 May 1909, W. M. Mann; 1 female; 26 May 1907; 1 female, 27 May 1902, C. V. Piper; 1 female, 1 June 1909; 1 female, 2 June 1907; 1 female, 7 June 1905.

The characters of *hesperia* are remarkably uniform, even from the extremes of its range, with the exception of a group of specimens (2 males, 4 females) from Gavilan, California, which are recognizably different from the majority of the specimens examined and are probably worthy of subspecific recognition.

***Nomada (Laminomada) hesperia falconis*, new subsp.**

*Male*.—Differs from typical *hesperia*, as described above, in more extensive yellow markings, including scutellar spots, a postscutellar line, arcuate marks on first abdominal sternite, and all tarsal segments. A paratype has, in addition, a large pleural spot with a tiny dot above, as well as tiny incipient spots on either side of propodeum.

*Female*.—Slightly larger than typical *hesperia*, and with more extensive yellow markings, including most of all coxae, a very large pleural spot joining a smaller round spot below wing bases, conspicuous propodeal spots, axillary spots, and the line under eye extending half-way up posterior orbit.

**SPECIMENS EXAMINED:** Gavilan (near Perris, Riverside Co.), California, 2 males (Type), 1 female (Allotype), 19 March 1936, on *Rhus trilobata*, P. H. Timberlake; 1 female, 27 March 1933, C. M. Dammers; 1 female, 1 April 1938, on *Plagiobothrys californicus*, P. H. Timberlake; 1 female, 7 April 1939, on *Cryptantha intermedia*, P. H. Timberlake. Type and allotype in collection of P. H. Timberlake.

It will be seen that the male of *falconis* is marked like the female of typical *hesperia*, while female *falconis* is much more yellow. The locality is the southernmost known for *hesperia*, and the subspecies may be indicative of what might be expected of specimens from farther south.

The season of flight in the various states in the range of *hesperia* is as follows:

California—Males	19 March	15 April
Females	19 March	22 April
Oregon (insufficient data)		
Washington—Males	18 April	18 May
Females	19 April	7 June

which indicates that the species flies about a month later at Pullman, Washington, than the average of the California dates. It may be noted that the season of subspecies *falconis*,

California—Males	19 March	
Females	19 March	7 April

corresponds to the early portion of the season of *hesperia*, but this may not prove to be significant in the light of subsequent collections.

## NOTES ON SOME GALL-INHABITING CHALCIDOIDEA (HYMENOPTERA)

A. B. GAHAN<sup>1</sup> and CH. FERRIÈRE<sup>2</sup>

A great many chalcidoids inhabit plant galls. By far the greater portion of these are parasitic upon the true gall makers, which may be dipterous, hymenopterous, lepidopterous, or hemipterous insects. However, a considerable number of chalcidoid genera and species are now known to be the cause of the galls which they inhabit. The number of these in comparison to the total number of gall-inhabiting forms is relatively small; yet in the aggregate they constitute a sizeable list of genera.

This gall-forming habit is found among several different groups of chalcidoids. One small group, represented by *Rhincopeltella* Girault, is placed among the Eulophidae because of its 4-segmented tarsi. Another group, composed of *Tanaostigma* Howard, *Tanaostigmodes* Ashmead, *Monopleurothrix* Mayr, *Cubaniella* Russo, *Eutetracera* Brethes, *Trichencyrtus* Ashmead, *Minapis* Brethes, and other related genera, and comprising the tribe Tanaostigmini, is apparently most closely related to the family Encyrtidae. In the Eurytomidae the gall-forming habits of *Harmolita* and related genera are well known. Still another group is made up of a number of genera which have been variously placed by different authors, some in Perilampidae, others in Pteromalidae, and still others in Miscogasteridae.

It is the purpose of this paper to deal only with the last indicated group of genera for which we shall use the tribal name Brachyscelidiphagini, a name first used by Girault (Mem. Queensland Mus., vol. 2, p. 309, 1913) as a tribal name in Pteromalidae. Subsequently Girault (Mem. Queensland Mus., vol. 5, pp. 222-226, 1916) transferred to the family Perilampidae, *Brachyscelidiphaga* and others of the genera which he originally included in the tribe. We have brought together under this tribal name several genera described by Ashmead, Mayr, Cameron, Crawford, and Girault. Very likely several other genera described by Girault belong here, but since no representatives of these were available and the descriptions are inadequate they have been omitted. Of the genera included, many are known to be gall formers. The biologies of others are as yet in doubt or entirely unknown. Although all seem to be closely related morphologically it would not be surprising if some should prove to be either partially or entirely parasitic.

In our opinion this group of genera is not closely related to Perilampidae. It does not have the well-defined supraclypeal area found in perilampids, the prepectus is not closely united with the lateral aspect of the pronotum, and the abdomen does not have the apical segments retracted. Most of the included genera would run in the classification by Ashmead to the family Miscogasteridae (Miscogaster-

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inae of Schmiedeknecht) because of the bicalcarate hind tibiae. Two or three of the included genera, however, have only one calcarium on the hind tibia, yet are obviously closely related to the forms having two calcaria. We are convinced that this character is unreliable as a means of separating major groups and that the family Miscogasteridae should be merged with the Pteromalidae. The genus *Miscogaster* Walker, upon which the family name Miscogasteridae is based, was synonymized with *Lamprotatus* Westwood by Walker (List Hymenoptera British Museum, Chalcidites, I, pp. 29-33, 1846) with the transfer of its genotype, *M. hortensis* (Curtis) Walker and many of the previously described species to Westwood's genus. Examination of types in the British Museum confirms this synonymy. Kloet and Hincks (Check List of British Insects, p. 189, 1945) have substituted the family name Lamprotatidae for Miscogasteridae. Since we consider the Lamprotatidae to be a part of the family Pteromalidae we have reduced the group to subfamily rank and made the present group a tribe of that subfamily.

### Family Pteromalidae

#### Subfamily Lamprotatinae

#### Tribe Brachyscelidiphagini

It is not easy to define this group. While the various forms have a common habitus somewhat different from other chalcidoids and by which they can usually be recognized at sight, there appears to be no structural character common to all of them which is not duplicated somewhere else in the Chalcidoidea. They differ from other lamprotatines chiefly by the more compact form of the thorax, the bidentate mandibles and the fact that the scutellum is usually without a transverse groove.

Body rather robust. Head, as viewed from in front, usually broader than high; clypeus more or less protruding beyond margin of head; mandibles bidentate, both teeth acute at apex, the inner one with a broadly rounded lobe on its inner margin; face flat or subconvex, never with a definite, set-off, supraclypeal area as in *Perilampus*; scrobal cavity not carinately margined; frons broad; ocelli in a low triangle; head, viewed from above, usually strongly transverse but occasionally rather thick anteroposteriorly; occiput never distinctly margined and rarely strongly concave; antenna with 11 to 13 segments. Prothorax short, the dorsal aspect of pronotum strongly transverse, rounded off in front and at sides, never carinately margined anteriorly; mesoscutum subconvex, never gibbous; parapsidal grooves complete and always widely separated at posterior ends; scutellum usually convex from side to side but occasionally nearly flat, sometimes produced at apex so as to overhang the metanotum but often not produced; mesopleuron with a distinct femoral impression; prepectus triangular, not jointed to posterior margin of lateral aspect of pronotum; propodeum rather short, without a neck. Hind tibia usually with two spurs, rarely with only one. Wings well developed. Abdomen sessile or subsessile, rarely with a short petiole; ovipositor never prominently exerted. Color usually yellow or black, very rarely metallic.

## KEY TO SOME GALL-INHABITING GENERA

1. Antennae inserted near clypeus; scutellum flat; axillae broadly separated. . . . . 2  
Antennae inserted nearer middle of head, at least on or above a line connect-  
ing the lower extremities of the eyes; scutellum usually strongly convex;  
axillae rarely broadly separated. . . . . 4
2. Scutellum with a punctate cross furrow; antennae 12-segmented, club 2-seg-  
mented. Coloration metallic. . . . . 1. *Eucoelocybomyia*  
Scutellum without a cross furrow; antennae with either 11 or 13 segments,  
club solid or with 3 segments. Coloration usually nonmetallic. . . . . 3
3. Antenna 11-segmented, club solid. . . . . 2. *Pareunotus*  
Antenna 13-segmented, club 3-segmented. . . . . 3. *Coelocyba*
4. Antenna 12-segmented. . . . . 5  
Antenna 13-segmented. . . . . 9
5. Funicular segments in the female transverse and produced dorsally into  
sawlike teeth, ramose in male. . . . . 4. *Terobiella*  
Funicular segments not produced dorsally in the female and not ramose in  
the male. . . . . 6
6. Antenna without a ring segment; axillae rather widely separated; postmar-  
ginal vein short. . . . . 7  
Antenna with one ring segment. . . . . 8
7. Marginal vein greatly thickened at base of stigmal vein; antennal club  
3-segmented. . . . . 5. *Leeuweniella*  
Marginal vein not thickened; antennal club 2-segmented. . . . . 6. *Epichrysomalla*
8. Axillae distinctly separated; postmarginal vein much longer than stigmal  
and about as long as marginal; antennal club 2-segmented, the segments  
distinctly separated; head and thorax more or less metallic. . . . . 7. *Cecidoxenus*  
Axillae meeting; postmarginal vein practically absent; antennal club 3-seg-  
mented, the segments not distinctly separated; head and thorax brownish  
testaceous. . . . . 8. *Eufroggattiana*
9. Antenna with 4 ring segments and 4 funicular segments; prepectus closely  
united to mesepimeron and with a prominent nodelike swelling at its  
dorsal margin; stigmal vein as long as or longer than marginal. . . . . 9. *Mayrellus*  
Antenna with less than 4 ring segments or with the flagellar segments all so  
much alike that it is impossible to distinguish between ring segments and  
funicular segments; stigmal vein usually shorter than marginal. . . . . 10
10. Forewing with a very distinct and strongly curved basal vein and the median  
vein also represented by a distinct fuscous line; basal vein in posterior  
wing distinct; postmarginal vein much longer than marginal; stigmal vein  
rather long and abruptly bent near middle; posterior tibia with only one  
spur. . . . . 10. *Espinosa*  
Forewing and hind wing with basal and median veins effaced; disagreeing  
with some of the other characters mentioned. . . . . 11
11. Antenna without true ring segments, the third antennal joint always longer  
than broad; scrobal cavity rather deep with the anterior ocellus located  
in its upper end. . . . . 11. *Perilampella*  
Antenna with at least the third segment transverse and ringlike; anterior  
ocellus located above the scrobal cavity. . . . . 12
12. Antenna with only 1 ring segment and 7 funicular segments, the fourth  
antennal segment much broader and longer than the third. . . . . 13  
Antenna with 2 or 3 distinct ring segments and 5 or 6 funicular segments  
(1 or more of the ring segments sometimes longer than broad) or with the  
antennal segments from 3 to 10 all transverse and becoming successively  
broader. . . . . 15
13. Stigmal vein very nearly perpendicular to anterior margin of wing, its knob  
bent at nearly a right angle to basal part; postmarginal vein reduced to  
a very short stub. . . . . 12. *Pembertonia*  
Stigmal vein not perpendicular to wing margin; postmarginal vein well  
developed. . . . . 14
14. Marginal vein narrow; stigmal vein elongate, the stigmal knob small; axillae  
meeting on median line of thorax. . . . . 13. *Lisseurytoma*  
Marginal vein thickened; stigmal vein short, its knob subsessile; axillae  
broadly separated. . . . . 14. *Asparagobius*

15. Posterior tibia with 1 spur ..... 16  
Posterior tibia with 2 spurs ..... 17
16. Antennal flagellum distinctly clavate, the segments between pedicel and club all transverse and successively increasing in width from first to last; scape short, not attaining anterior ocellus; scutellum not carinately margined ..... 15. *Brachyscelidiphaga*  
Antennal flagellum weakly clavate, the first two segments between pedicel and club small and ringlike, the following segments all at least as long as broad; scape attaining level of vertex; scutellum carinately margined at apex ..... 16. *Perilampomyia*
17. Posterior femur swollen and armed beneath a little beyond the middle with a broad blunt toothlike projection; abdomen not longer than thorax and strongly compressed from the sides ..... 17. *Systolomorpha*  
Posterior femur not especially swollen and without a toothlike projection; abdomen not strongly compressed ..... 18
18. Axillae broadly separated ..... 18. *Hemadas*  
Axillae touching or very narrowly separated ..... 19
19. Antenna with 3 ring segments; stigmal vein about half as long as marginal, with a rather large rounded knob; axillae slightly separated, 19. *Coelocybella*  
Antenna with only 2 ring segments; stigmal knob rarely large; axillae usually touching ..... 20
20. Thorax dorsally either perfectly smooth finely lineolated, or with shallow reticulate punctate sculpture, always more or less shining; antennae inserted above lower extremities of eyes ..... 21  
Thorax strongly sculptured, either umbilicately punctate or densely and finely rugulose-punctate, dull; antennae inserted on a line with lower extremities of eyes ..... 23
21. Marginal vein thickened; wings with discal ciliation usually subobsolete (normal in *trilineata* Cam.) ..... 20. *Trichilogaster*  
Marginal vein not thickened; discal ciliation normal, sometimes quite dense ..... 22
22. Forewing hyaline; axillae slightly separated ..... 21. *Coelocybelliodes*  
Forewing infuscated, especially on the anterior part behind marginal and postmarginal veins; axillae joined ..... 22. *Trichilogastroides*
23. Dorsum of thorax with distinctly umbilicate punctures; stigmal vein strongly and evenly curved from base to apex, much shorter than marginal vein; pedicel about one and one-half times as long as thick ..... 23. *Decatomothorax*  
Dorsum of thorax finely and densely rugulose-punctate; stigmal vein nearly straight, nearly as long as marginal vein; pedicel two and one-half times as long as thick ..... 24. *Alloderma*

### 1. Genus *Eucoelocybomyia* Girault

*Eucoelocybomyia* Girault, Mem. Queensland Mus., vol. 3, p. 306, 1915.

This genus has been placed in the key solely on the basis of Girault's description. The only described species, *E. aerea* Girault, is said to have been reared from galls on young gum trees (*Eucalyptus*) at Melbourne, Victoria, Australia.

The metallic coloration and the presence of a transverse row of punctures on the scutellum suggest that this genus may belong to the tribe Tridymini rather than to Brachyscelidiphagini.

### 2. Genus *Pareunotus* Girault

*Pareunotus* Girault, Mem. Queensland Mus., vol. 3, p. 323, 1915.

*Paracoelocyba* Girault, Mem. Queensland Mus., vol. 5, p. 223, 1916.

The above generic synonymy was stated by Girault in one of his privately published pamphlets (Indications [in New Insects] of Ruling Power and Law in Nature, p. 3, 1925). Four species, all from Australia, are indicated as belonging in the genus, viz.: *Pareunotus flavicarpus* Gir., *Paracoelocyba acincta* Gir., *minuta* Gir. and *varifasciata* Gir. In

the original description of *Pareunotus* (of which *P. flavicarpus* is the genotype) the antennae were said to be 10-segmented, but in the later description of *Paracoelocyba* (of which *P. acincta* is the genotype) they are stated to be 11-segmented. The present authors have seen neither genotype, but a paratype of *minuta* which is in the United States National Museum has the antenna short, 11-segmented, strongly clavate, the eight segments between pedicel and club all transverse and increasing successively in width from first to last, the club solid and much thicker than the pedicel.

### 3. Genus *Coelocyba* Ashmead

(Figs. 1 and 1a)

*Coelocyba* Ashmead, Proc. Linn. Soc. N. S. Wales, vol. 25, p. 344, 1900.

*Coelocybomyia* Girault, Mem. Queensland Mus., vol. 3, p. 304, 1915; vol. 5, p. 222, 1916.

The synonymy of *Coelocybomyia* with *Coelocyba* was recorded by Girault in the 1916 publication cited above. We have seen only the genotype of *Coelocyba*, *C. nigrocincta* Ashmead, which is represented in the United States National Museum collection by more than 40 specimens, including the type series, and in the British Museum by 5 specimens previously standing under an unpublished Cameron manuscript name. The types of *C. nigrocincta* are said to have been bred from galls of an agromyzid on *Eucalyptus corymbosa* at Sydney, New South Wales. Girault has described several additional species from Australia. Some of these he subsequently referred to other genera. The four species described by him in *Coelocybomyia* (viz., *sexfasciata*, *novisextfasciata*, *persimilis*, and *nigriventris*), judged by the descriptions, seem to be nothing more than color variations of *nigrocincta* Ashm. Two of the four are recorded as reared from "aborted capsules of red gum caused by a dipterous larva, *Agromyza* sp.," while another is said to have been reared from galls on young gum.

According to N. S. Noble (Proc. Linn. Soc. N. S. Wales, vol. 66, p. 193, 1941), *C. nigrocincta* Ashm. was reared by him from galls made by the chalcids *Tepperella trilineata* Cam., *Trichilogaster maideni* Frogg. and *T. acaciae-longifoliae* Frogg. on *Acacia* spp. His observations show that in some cases, at least, *C. nigrocincta* destroys the gall-maker larvae.

It appears probable *nigrocincta* is a true parasite and not a gall maker.

A list of the species and their probable synonymy follows:

*Coelocyba nigrocincta* Ashm., Proc. Linn. Soc. N. S. Wales, vol. 25, p. 344, 1900.

Syn., *Coelocybomyia nigriventris* Gir., Mem. Queensland Mus., vol. 3, p. 305, 1915. New synonymy.

Syn., *Coelocybomyia persimilis* Gir., Mem. Queensland Mus., vol. 3, p. 305, 1915. New synonymy.

Syn., *Coelocybomyia sexfasciata* Gir., Mem. Queensland Mus., vol. 3, p. 304, 1915. New synonymy.

Syn., *Coelocybomyia novisextfasciata* Gir., Mem. Queensland Mus., vol. 3, p. 304, 1915. New synonymy.

*Coelocyba turneri* Gir., A New Habit in an Old Insect, *Homo pudicus* and New Eurytomidae, p. 1, 1931.

*Coelocyba varicincta* Gir., Insecutor Inscitiae Menstruus, vol. 14, p. 66, 1926.



4. Genus *Terobiella* Ashmead

(Fig. 2)

*Terobiella* Ashmead, Proc. Linn. Soc. N. S. Wales, vol. 25, p. 343, 1900.*Paraterobia* Ashmead, Mem. Carnegie Mus., vol. 1, p. 274, 1904. New synonymy.*Tepperella* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 36, pt. 4, p. 652, 1911. New synonymy.*Perilampoides* Girault, Mem. Queensland Mus., vol. 2, p. 302, 1913.*Melanosomella* Girault, Can. Ent., vol. 45, p. 222, 1913.

The genotype of *Paraterobia* (*P. nigriceps* Ashm.) is wholly congeneric with the genotype of *Terobiella* (*T. flavifrons* Ashm.) but a different species. Types of both species are in the United States National Museum. The genotype of *Perilampoides* (*P. bicolor* Gir.) is in the Queensland Museum and has not been seen, but the description of the genus seems not to differ materially from *Terobiella* and Girault has redescribed the type specimen of *Paraterobia nigriceps* as *Perilampoides aurantiscutum* (Mem. Queensland Mus., vol. 5, p. 224, 1916). The genotype of *Melanosomella* (*M. flavipes* Girault) has been synonymized with *Terobiella flavifrons* Ashm. by Girault (Mem. Queensland Mus., vol. 5, p. 222, 1916).

*Tepperella* has as its genotype *T. maculiscutis* Cam., the type of which is in the British Museum. It has been examined by the junior author and found to belong in *Terobiella* and to be a synonym of *nigriceps* (Ashm.). One other species described by Cameron as *Tepperella trilineata* is here transferred to *Trichilogaster*. Several additional species which are unknown to us have been described by Girault and one by Gallard.

A list of the species follows:

*Terobiella adolphi* (Gir.), new combination.Syn., *Perilampoides adolphi* Gir., A New Habit in an Old Insect, Homo pudicus and New Eurytomidae, p. 1, 1931.*Terobiella bicolor* (Gir.), new combination.Syn., *Perilampoides bicolor*, Mem. Queensland Mus., vol. 2, p. 302, 1913.*Terobiella blackburni* (Gir.), new combination.Syn., *Tepperella blackburni* Gir., Some New Hexapoda Stolen from Authority, p. 2, 1928.*Terobiella cinctitibiae* (Gir.), new combination.Syn., *Perilampoides cinctitibiae* Gir., A New Habit in an Old Insect, Homo pudicus and New Eurytomidae, p. 1, 1931.*Terobiella dilutiventris* (Gir.), new combination.Syn., *Epiperilampus dilutiventris* Gir., Mem. Queensland Mus., vol. 2, p. 301, 1913.*Terobiella eucalypti* (Gallard), new combination.Syn., *Tepperella eucalypti* Gallard, Australian Naturalist, vol. 8, p. 40, 1930.*Terobiella flavifrons* Ashm., Proc. Linn. Soc. N. S. Wales, vol. 25, p. 343, 1900.Syn., *Melanosomella flavipes* Gir., Mem. Queensland Mus., vol. 5, p. 222, 1916.*Terobiella flavithorax* (Gir.), new combination.Syn., *Perilampoides flavithorax* Gir., Mem. Queensland Mus., vol. 3, p. 303, 1915.*Terobiella nigriceps* (Ashm.), new combination.Syn., *Paraterobia nigriceps* Ashm., Mem. Carnegie Mus., vol. 1, p. 274, 1904.Syn., *Tepperella maculiscutis* Cam., Proc. Linn. Soc. N. S. Wales, vol. 36, p. 653, 1911. New synonymy.

Syn., *Perilampoides aurantiscutum* Gir., Mem. Queensland Mus., vol. 5, p. 224, 1916. Note.—In the Giraultian pamphlet, "A New Habit in an Old Insect, Homo Pudicus and New Eurytomidae," pp. 1 and 2, 1931, he has proposed three varieties or subspecies of *aurantiscutum*, viz. *regis*, *rex* and *anna*, despite the fact that he had himself synonymized *aurantiscutum* many years previously. These forms have not been seen by the writers and are not recognizable from the descriptions.

*Terobiella particolor* (Gir.), new combination.

Syn., *Perilampoides particolor* Gir., Mem. Queensland Mus., vol. 3, p. 303, 1915.

*Terobiella regalis* (Gir.), new combination.

Syn., *Perilampoides regalis* Gir., A New Habit in an Old Insect, Homo pudicus and New Eurytomidae, p. 2, 1931.

*Terobiella scutatus* (Gir.), new combination.

Syn., *Perilampoides scutatus* Gir., loc. cit., p. 1, 1931.

*Terobiella similis* (Gir.), new combination.

Syn., *Perilampoides similis* Gir., Insecutor Inscitiae Menstruus, vol. 5, p. 147, 1917.

*Terobiella sismondi* Gir., A New Habit in an Old Insect, Homo pudicus and New Eurytomidae, p. 2, 1931.

*Terobiella tennysoni* (Gir.), new combination.

Syn., *Perilampoides tennysoni* Gir., Insecutor Inscitiae Menstruus, vol. 8, p. 50, 1920.

Species for which rearing records are available all inhabit galls on *Eucalyptus* and are believed to be the gall makers. The genus is known only from Australia.

#### 5. Genus *Leeuweniella* Ferrière

*Leeuweniella* Ferrière, Ann. Soc. Ent. de France, vol. 98, p. 148, 1929.

*Leeuweniella ficophila* Ferr. is closely related to *Epichrysomalla atricorpus* Gir., but is clearly distinct by the strong thickening of the veins at the base of the stigmal vein. The original description is not quite correct in that the antenna has only one and not two annelli; what had been considered as a short first annellus is in reality the small petiole between pedicel and first flagellar joint; the antenna is 12-jointed with no real ring joint. Moreover, the axillae do not meet in the middle in dry specimens.

The only known species makes galls on *Ficus recurva* Bl. in Java.

#### 6. Genus *Epichrysomalla* Girault

*Epichrysomalla* Girault, Mem. Queensland Mus., vol. 3, p. 309, 1915.

The only described species of this genus, *E. atricorpus* Girault, is said to have emerged from a cluster of capsulelike galls in a ripe fig collected at Gordonvale, Queensland, Australia.

#### 7. Genus *Cecidoxenus* Ashmead

(Figs. 3 and 3a)

*Cecidoxenus* Ashmead, Mem. Carnegie Mus., vol. 1, p. 274, 1904.

*Parachrysomalla* Girault, Mem. Queensland Mus., vol. 3, p. 309, 1915. New synonymy.

The genotype, *C. nigrocyaneus* Ashm., was described only in Ashmead's key to genera of Tridymini. Ashmead's type specimens were redescribed by Girault under the name *Parachrysomalla secunda* (Insecutor Inscitiae Menstruus, vol. 5, p. 154, 1917). The genotype of *Parachrysomalla* is *P. aerifemur* Girault. No representatives of this species have been available for examination. However, the generic description of *Parachrysomalla* offers no tangible characters to separate that genus from *Cecidoxenus*, and since Girault, as already indicated, placed the genotype of *Cecidoxenus* in *Parachrysomalla* it is evident that *Parachrysomalla* is a synonym.

The species *aerifemur* is apparently different from *nigrocyaneus*. Both species are Australian and nothing seems to be known about their

biologies except that the types of *C. nigrocyaneus* in the United States National Museum are labeled, "Turpentine galls, Flemington." Flemington is in New South Wales.

#### 8. Genus *Eufroggattiana*, new name (Gahan)

(Figs. 4 and 4a)

*Froggattia* Ashmead (not Horvath, 1902), Mem. Carnegie Mus., vol. 1, p. 238, 1904.  
*Eufroggattia* Ashmead (not Goding, 1903), Proc. Ent. Soc. Washington, vol. 6, p. 126, 1904.

Two species have been described in this genus. *Froggattia polita* (Ashm.), the genotype, was described from one specimen collected at Sydney, New South Wales. The other species is *Eufroggattia okinawensis* Ishii (Kontyu, vol. 8, p. 94, 1934) collected from fruits of *Ficus retusa* L at Naha, Okinawa, Japan.

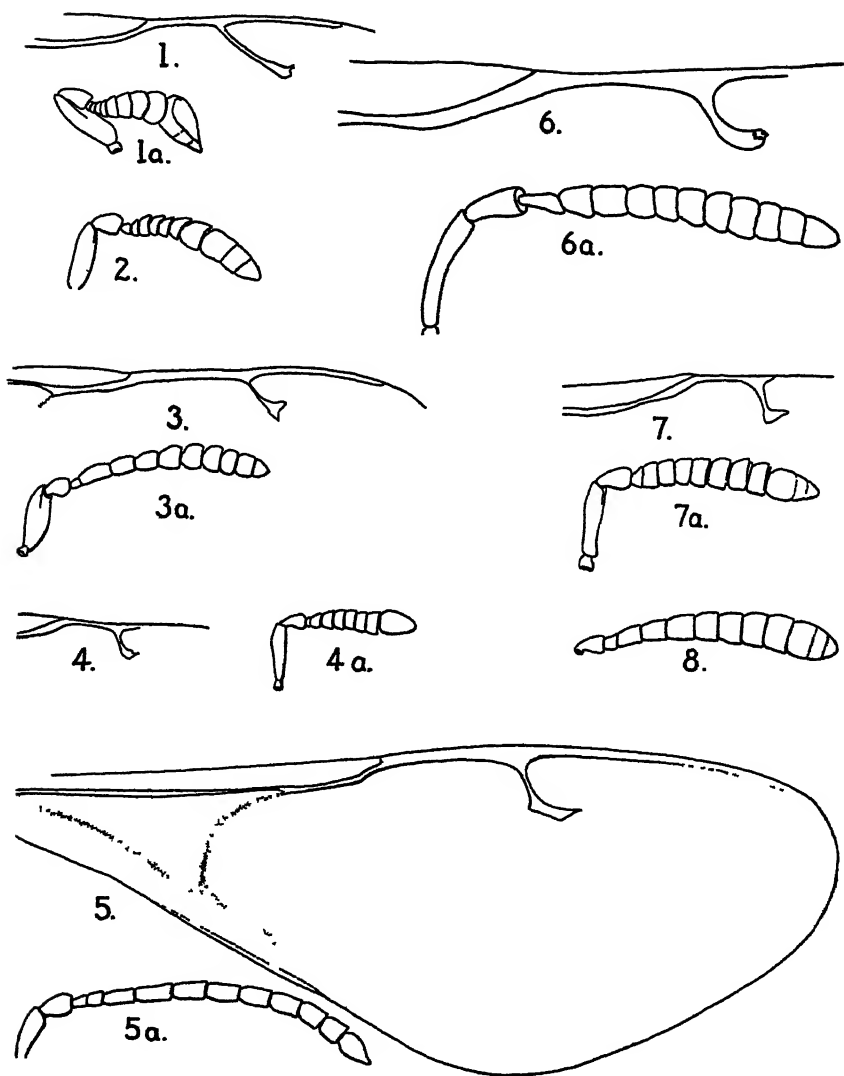
This genus was placed by Ashmead in the subfamily Idarninae, a group with which it seems to have little affinity. It will not run satisfactorily to Idarninae in Ashmead's keys, since the hind tibia has two distinct spurs, the mesepisternum is not incised, and the ovipositor does not project beyond the apex of abdomen.

The antenna of *E. polita* is 12-segmented (10-segmented if the club is considered to be solid) with the scape subcylindrical, the pedicel half as long as the scape and about twice as long as thick, the single ring segment transverse, the six funicular segments each broader than long and increasing slightly in breadth from first to last, the club very indistinctly 3-segmented and a little longer than the two preceding segments combined. Pronotum much broader than long, as broad as prescutum but narrower than mesonotum at tegulae, not narrowing anteriorly, strongly declivous dorsally from posterior to anterior margin and with a weak transverse carina behind the middle. Mesoscutum with deep and weakly foveolate parapsidal grooves, the prescutum with one long bristle near each anterolateral angle, another on each side about halfway between base and apex and a pair at posterior ends of parapsidal grooves; axillae meeting on the median line; scutellum moderately convex,

#### EXPLANATION OF FIGURES\*

- FIG. 1. *Coelocyba nigrocincta* Ashmead. Venation of forewing.  
 FIG. 1a. *Coelocyba nigrocincta* Ashmead. Antenna of female.  
 FIG. 2. *Terobiella nigriceps* (Ashmead). Antenna of female.  
 FIG. 3. *Cecidoxenus nigrocyaneus* Ashmead. Venation of forewing.  
 FIG. 3a. *Cecidoxenus nigrocyaneus* Ashmead. Antenna of female.  
 FIG. 4. *Eufroggattiana polita* (Ashmead). Venation of forewing.  
 FIG. 4a. *Eufroggattiana polita* (Ashmead). Antenna of female.  
 FIG. 5. *Espinosa nothofagi* Gahan. Venation of forewing.  
 FIG. 5a. *Espinosa nothofagi* Gahan. Antenna of female.  
 FIG. 6. *Perilampella scindapsi* Ferrière. Venation of forewing.  
 FIG. 6a. *Perilampella scindapsi* Ferrière. Antenna of female.  
 FIG. 7. *Pembertonia ficiicola* Gahan. Venation of forewing.  
 FIG. 7a. *Pembertonia ficiicola* Gahan. Antenna of female.  
 FIG. 8. *Lisseurytoma bicolor* Gahan. Antenna of female.

\*Figures 1 to 5a, 7 to 8 and 11 to 14 were drawn by Arthur D. Cushman, scientific illustrator for the Division of Insect Identification, United States Bureau of Entomology and Plant Quarantine. All other figures were furnished by Ch. Ferrière, junior author.



without a cross furrow, and with one long bristle on each side midway between base and apex and a pair at extreme apex. Propodeum with a broad foveolated depression along its anterior margin and a narrow extension of this down the middle, the lateral folds weak and obscure, the spiracular grooves broad and foveolated, the spiracles ellipsoidal and moderately large. Front wing weakly ciliated; stigmal vein a little more than half as long as the marginal and with a rather slender knob; postmarginal vein very short, practically effaced. Abdomen very shortly petiolate, subcompressed from the sides, about as long as head and thorax combined, the ovipositor not exerted.

With the exceptions of some very faint reticulation on the mesoscutum, pleura and apical segments of the abdomen and the foveolated areas on the propodeum the whole integument is practically smooth and shining. The color is reddish yellow with the propodeum and abdomen dark brownish and the antennal flagellum dark brown. The wings are hyaline.

*E. polita* may be distinguished from *okinavensis* Ishii by antennal characters, by the fact that the scutellum has only two instead of four pairs of bristles and by the hyaline wings.

#### 9. Genus *Mayrellus* Crawford

*Mayrellus* Crawford, Proc. U. S. Natl. Mus., vol. 39, p. 237, figs. 3, 4, 1910.

*Mayrellus mirabilis* Crawford, the genotype, is represented in the United States National Museum collection by 13 specimens, representing both sexes, reared from a gall on an unidentified plant collected at Ceara, Brazil. It is believed to have been the gall maker.

The genus and species are well characterized in the original description except that the unusual conformation of the prepectus is not mentioned. This sclerite is rather small, very closely united to the mesepimeron but separated from it by a fine shallow groove, and swollen at its dorsal margin to form a prominent tubercle just in front of the tegula. Also the antennal club is 3-segmented, the segments plainly indicated by shallow grooves, not completely fused as was indicated in the original figure.

#### 10. Genus *Espinosa*, new (Gahan)

In having 13-segmented antennae and only one spur on the hind tibia this genus agrees with *Perilampomyia* Girault but in venation and sculpture it is quite different. The presence of very distinct though more or less obsolescent basal veins in both the front and hind wings distinguishes it from all other genera here treated and from nearly all other genera of Chalcidoidea as well. Quite similar obsolescent basal veins are found in *Aiolomorphus* Walker, but here they are less distinct and the two genera are radically different in the shape of the body, in sculpture, in details of venation, and several other respects.

*Female*.—Head, viewed from in front, somewhat broader than high; clypeus subquadrate, projecting beyond margin of head and squarely truncate at apex, clypeal foveae large and deep; scrobes short; eyes occupying about two-thirds of height of head. Head viewed from above about twice as broad as long; frons broad; ocelli in a low broad triangle, each lateral one about twice its own diameters from the eye margin;

occiput not margined, not concave, sloping somewhat from the vertex. Antenna 13-segmented, the flagellum filiform, without a distinctly differentiated club; scape short, two and a half to three times as long as broad, slightly compressed; pedicel about half as long as scape and one and a half times as long as broad; two subequal and distinct ring segments; nine following segments all equally well separated, the apical segment pointed ovate and one and one-half times as long as penultimate.

Pronotum very short, much below level of mesonotum and mostly concealed beneath it; mesoscutum a little broader than long, moderately convex, with deeply impressed and complete parapsidal grooves which are widely separated at posterior margin of mesoscutum; axillae large and nearly meeting on the median line; scutellum convex, distinctly longer than broad, immargined except at apex, projecting slightly over metathorax, and with a transverse depression or groove (often poorly defined) a little before apex; prepectus moderately large; femoral furrow deeply impressed. Propodeum rather short, convex medially, with a median longitudinal carina, weak lateral folds and deep spiracular furrows, the spiracles circular and close to anterior margin of propodeum. Hind tibia with only one spur. Forewings extending much beyond apex of abdomen, a little more than two and one-half times as long as broad; basal vein obsolescent but very distinct, strongly curved, median vein also represented by a fuscous line; stigmal vein long, sharply elbowed near the middle, its apical abscissa slightly thicker than the basal abscissa and forming nearly a right angle with it, without a knob; marginal vein a little less than twice as long as stigmal, not thickened; postmarginal vein nearly twice as long as marginal. Abdomen sessile, subcompressed, about as long as thorax, the ovipositor not exerted.

*Male*.—Antenna distinctly longer than in the female, the scape about twice as long as broad, pedicel as long as broad, ring segments a little broader than long, flagellar joints cylindrical and three to four times as long as thick; abdomen shorter than thorax, sessile, and subcompressed. Otherwise like the female.

*Genotype*.—*Espinosa nothofagi*, new species. Genus named for the collector.

***Espinosa nothofagi*, new species (Gahan)**

(Figs. 5 and 5a)

*Female*.—Length 3.2 mm. Brownish black; legs, including anterior and middle coxae, yellowish testaceous, hind coxae brownish black; tegulae yellowish; mandibles reddish; antennae uniformly brownish black; wings hyaline, the venation, including basal and median veins, dark brown; abdomen usually more or less castaneous at base. Ring segments of antenna each a little longer than broad; 5th and 6th antennal segments subequal and approximately two and one-half times as long as thick; 7th to 10th segments subequal and each about twice as long as thick; 11th and 12th segments shorter but each longer than thick; 13th segment not broader than penultimate and about twice as long as thick. Eyes bare; malar space equal to about one-third eye height. Forewing with sparse discal cilia in basal and median cells, rather densely ciliated basad of basal vein, and with a short marginal fringe.

Integument of head and thorax nearly smooth but with faint reticulation, the clypeal region more or less rugulose and reticulation of axillae more distinct than on mesoscutum and scutellum.

*Male*.—Length 3 mm. Ring segments of antenna a little broader than long; 5th antennal segment nearly four times as long as thick, following segments to the 12th successively diminishing slightly in length; 12th segment a little less than three times as long as thick, and 13th somewhat longer and a little thicker than preceding.

*Type locality*.—Santiago, Chile.

*Type*.—United States National Museum No. 58131.

Female holotype and three female paratypes received from Carlos E. Porter and said to have been reared October 24, 1928, from galls on "Chilean oak" (*Nothofagus* sp.), by Professor M. R. Espinosa, after whom I have named the genus. The male allotype and six female paratypes were reared from galls on *Nothofagus obliqua* at Angol, Chile, November 9, 1926, by D. S. Bullock.

#### 11. Genus *Perilampella* Girault

*Perilampella* Girault, Mem. Queensland Mus., vol. 3, p. 308, 1915.

The biology of the genotype species, *P. flammeithorax* Gir., from New South Wales, Australia, is unknown. Two other species, *P. signiventris* and *P. punctata*, have been described by Girault (A New Habit in an Old Insect, *Homo Pudicus* and New Eurytomidae, p. 2, 1931) from New South Wales without indication of their host relations. A fourth species, *P. raphidophorae* Ferrière (Ann. Soc. Ent. de France, vol. 98, p. 154, 1929), was reared from a gall on *Raphidophora montana* in Java, and a fifth species, description of which follows, makes galls on *Scindapsus* in Sumatra.

#### *Perilampella scindapsi*, new species (Ferrière)

(Figs. 6 and 6a)

Body black, shining, with greenish reflections on face, frons and cheeks. Antennae of female dark brown with scape and pedicel yellow, and the first joint of the flagellum light brown. Antennae of male entirely yellow. Legs black, knees, front and middle tibiae and all tarsi yellow. The male has also the femora yellow, except the hind femora at base. Wings yellowish with a dark cross band below the end of the submarginal vein.

*Female*.—Head transverse; ocelli in a low triangle, the lateral ocelli farther from the eyes than from the front ocellus; this front ocellus situated in the top of the scrobal cavity. Frons and face smooth, with few scattered punctures. Antennae inserted above the middle of the face, about level with the middle of the eyes, with 13 joints; scape narrow, reaching the front ocellus; pedicel about twice as long as broad; first joint of the flagellum (annellus) narrower and a little shorter than the pedicel, broadening towards tip; following joints as broad as the pedicel but shorter, the last joints transverse. Pronotum short, with scattered punctation and ciliation. Mesonotum smooth, parapsidal furrows strong, slightly punctate. Scutellum strongly convex, smooth in the middle, punctate on the sides, separated from the mesonotum by a deep furrow; axillae small, on the sides of the scutellum. Propodeum

short, almost vertical, reticulated. Wings large; submarginal vein somewhat thickened and black at tip; marginal vein discolored, short but about thrice as long as the postmarginal vein; stigmal vein brown, about as long as two-thirds of the marginal. Legs strong, hind tibiae with two spurs, tarsi short. Abdomen as long as head and thorax together, slightly compressed from the sides; first segments smooth, the last large and rugulose above, except along the middle. Ovipositor not protruding, curved inside the abdomen.

*Male*—Similar, smaller, with the abdomen depressed and scarcely longer than the thorax.

Length, female 2.9–3.2 mm., male 2 mm.

Sumatra, Fort de Kock, 920 m., 4 females, 1 male, 1924 (E. Jacobson).

Produces galls on the leaf petioles of *Scindapsus roseus* v. A. v. R. (Araceae).

Type—British Museum (Natural History).

This species may be distinguished from *Perilampella raphidophorae* Ferr. by the greenish face and frons, the more smooth and shining thorax, the black and compressed abdomen, with the last joint narrower and more rugulose, and by the marginal vein which is longer in relation with the stigmal vein. The ovipositor, although entirely hidden, is remarkable by its length, being rolled up three times inside the abdomen which it fills almost entirely.

## 12. Genus *Pembertonia*, new (Gahan)

This genus agrees with *Eufroggattiana* in many respects and is undoubtedly closely related to it, but differs by having 13-segmented antennae and a differently shaped and nonpetiolate abdomen. The very short postmarginal vein will distinguish it from all other genera treated here.

*Female*.—Head viewed from in front broader than high; clypeus about as broad as long, projecting somewhat beyond margin of head, and weakly bilobate at apex; clypeal fovea shallow; scrobes moderately impressed, extending to front ocellus, immargined; eyes occupying about two-thirds of height of head, malar furrow incomplete. Head viewed from above a little more than twice as broad as long; frons broad; ocelli in a low triangle, each lateral one about twice its own diameter from eye margin; occiput not concave, weakly carinately margined far below vertex. Antenna 13-segmented; scape subcylindrical, about four and one-half times as long as thick; pedicel a little less than twice as long as thick; one ring segment, nearly as broad as long; funicle 7-segmented, the segments subequal, a little broader than pedicel and each about twice as broad as long; club ovate, nearly as long as three preceding segments combined, 3-segmented, the separating furrows distinct but shallow.

Prothorax transverse, not narrowed anteriorly, rounded at anterior angles, lower than mesoscutum but not covered by it, strongly declivous from posterior to anterior margin, with a weak and incomplete transverse carina a little behind the middle and with numerous long slender hairs scattered over most of its surface. Mesoscutum broader than long; parapsidal grooves deep, complete, and widely separated at posterior ends; prescutum mostly bare but with an irregular row of hairs



along each lateral margin; parapsides with numerous hairs near the tegulae and two or three along each parapsidal groove; axillae large, touching on the median line, separated from scutellum by deep foveolated grooves and with three or four long hairs; scutellum moderately convex, margined at apex, not projecting over metathorax, without a cross furrow and without paired bristles but with about 12 long hairs low down on each side. Propodeum about half as long as scutellum, more or less rugulose, depressed medially on each side of a median longitudinal carina, the depressions continuous with a foveolated depression along anterior margin; lateral folds and spiracular furrows present; spiracle elliptical and about its own diameter from anterior margin. Prepectus triangular, not large; femoral furrow broad, not deeply impressed. Hind tibia with two distinct spurs; anterior tibial spur originating about its own length before apex of tibia and bifid at apex.

Forewing extending beyond apex of abdomen, length to breadth as 40 : 15; submarginal vein about five times as long as marginal, this latter slender; stigmal vein approximately three-fourths as long as marginal and forming very nearly a right angle with it, boot-shaped, its apex bent at practically a right angle to the straight basal abscissa and slightly thicker than the remainder of vein; postmarginal vein represented by a very short stub; basal and median veins entirely absent.

Abdomen about as long as thorax, ovate, sessile, not compressed, the basal segment incised at apex. Ovipositor not exerted.

*Male*.—Unknown.

*Genotype*.—*Pembertonia ficicola*, new species. Genus named for the collector.

***Pembertonia ficicola*, new species (Gahan)**

(Figs. 7 and 7a)

*Female*.—Length 3.5 mm. Head castaneous above and behind, the face and cheeks reddish yellow; mandibles and narrow anterior margin of clypeus dark reddish; antennal scape yellow, flagellum brownish black; prothorax anteriorly concolorous with back of head, posteriorly with a broad marginal band of yellow and more or less yellowish on the sides; mesothorax, metathorax and propodeum black; coxae, femora, and tibiae reddish black, the front tibiae shading to yellowish; all tarsi reddish yellow; wings mostly hyaline but with a small brownish infuscation against the curved apical portion of submarginal vein and another similar spot midway between this and the posterior margin of wing. Abdomen mostly black, but diluted with yellowish ventrally and at extreme base above.

Head more distinctly sculptured than dorsum of thorax; vertex finely transversely ruguloso-striate; frons with fine longitudinal striae originating at anterior ocellus and running downward on each side of scrobe; scrobal cavity weakly reticulated; face with weak rugulae converging toward clypeus, a slight median ridge and the clypeus nearly smooth; cheeks polished; temples weakly rugulose. Eyes bare; lateral ocelli twice their own diameters from eye margins. Pronotum smooth dorsally, finely ruguloso-striate anteriorly and laterally; mesoscutum, axillae, and scutellum shining, with some very faint, suberased lineola-

tion; propodeum rugosely sculptured, with a carinately bounded, subquadrate or rounded area on each side of middle more weakly sculptured; pleura rather strongly ruguloso-striate. Front wing bare at base, sparsely and weakly ciliated on the disk; fringe absent except on the posterior margin where it is very short.

*Type locality*.—Sydney, Australia.

*Type*.—United States National Museum No. 58132.

Described from two females (1 holotype) labeled as having been reared from *Ficus macrophylla* in January, 1921, by C. E. Pemberton.

### 13. Genus *Lisseurytoma* Cameron

*Lisseurytoma* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 37, p. 202, 1912.

*Cratodecatoma* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 37, p. 205, 1912. New synonymy.

Cameron first described the genus *Lisseurytoma*, which he placed near *Eurytoma*; he knew only the male and remarked that the pronotum is not developed as much as in *Eurytoma* and is narrowed in front; he says also that the hind tibiae have only one spur, when in reality they have two, the second being small but nevertheless visible. Three pages farther, he describes the genus *Cratodecatoma*, in the tribe Decatomini, from the female. He recognizes that this new genus differs in many points from *Decatoma*, adding that when the male has been found, it may have to be placed somewhere else. It is curious that he did not recognize that the male, bred from the same galls on *Casuarina* sp., at the same time, had been described by him in another genus.

We give a redescription of Cameron's types, which are in the British Museum.

#### *Lisseurytoma bicolor*, new species (Gahan)

(Fig. 8)

Agreeing very closely with the accompanying description of *violaceitincta*, except that the head and thorax are uniformly pale orange yellow, the scutellum not at all blackish, the antennae appear to be more strongly clavate, and the base of abdomen is perfectly smooth.

*Female*.—Length 4.75 mm. Head and thorax uniformly pale orange yellow; metanotum, propodeum, and abdomen blackish brown, this color more or less diluted with yellowish at base of abdomen; legs blackish brown, a little less dark than propodeum, their tarsi yellow; antennal scape and pedicel yellow, flagellum brownish black. Anterior wing with a large fuscous cloud extending from base of marginal vein to a point well beyond apex of stigmal vein, the distal margin of this cloud broadly convex, its proximal margin nearly straight.

Head finely and densely sculptured. Antennal scape just reaching lower margin of anterior ocellus; pedicel about one and a half times as long as broad; ring segment a little broader than long; flagellum rather strongly clavate, gradually increasing in thickness from pedicel to club; first, second, and third funicular segments subequal and each about as long as pedicel; following segments decreasing in length, the seventh about twice as broad as long; club fully twice the width of pedicel and slightly longer than two preceding segments combined, with two distinct cross furrows. Thorax finely ruguloso-punctate, the rugulae on dorsum showing a slight tendency toward transverseness; propodeum

with distinct lateral folds and a median carina, the surface between the folds rugulose, laterad of folds practically smooth. Abdomen with a rather thick petiole which is about as long as broad and weakly sculptured; first segment of gaster deeply incised at apical middle, smooth; following tergites faintly shagreened. Other characters agreeing with the description of *violaceitincta*.

*Male*.—Length 2.8 mm. Head, thorax, and abdomen black; legs and antennae brownish black, tarsi yellow; wings perfectly hyaline, venation yellowish. Antennal pedicel scarcely longer than broad; flagellum not thicker at apex than at base, the segments subequal and subquadrate. Sculpture of head and thorax similar to that of female but slightly coarser. Abdomen much shorter than thorax, smooth.

*Type locality*.—Gosford, New South Wales, Australia.

*Type*.—United States National Museum No. 58137.

Described from five females and four males. The holotype female is labeled "Casuarina galls, Gosford, N. S. W., W. W. F., 1913." Four other females and all of the males are labeled "Casuarina galls, Sydney, N. S. Wales, (Froggatt), 1913," with an illegible word that may be "Gosford" written in the corner of each label.

It is quite possible that this may prove to be merely a color form of *violaceitincta*, the types of which appear to have been obtained from the same host plant and locality.

### *Lisseurytoma violaceitincta* Cameron

(Figs. 9 and 9a)

*Lisseurytoma violaceitincta* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 37, p. 202, 1912.

*Craiodactoma ruficeps* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 37, p. 206, 1912. New synonymy.

*Female*.—Head orange yellow, the face darker; stemmaticum and occiput brownish. Pronotum brown in front, orange yellow behind; axillae reddish yellow; scutellum, except slightly in front, postscutellum and propodeum black. Abdomen orange yellow anteriorly, more brownish towards tip. Antenna brown with scape, pedicel, annellus and the first two or three funicle joints yellowish. Legs brownish black, tarsi yellow. Wings hyaline, with a broad infuscation in the middle, below the marginal and postmarginal veins.

Head shagreened, dull, rounded in front, narrowed behind the eyes. Antennae inserted near the middle of the face; scape narrow, not reaching the front ocellus; pedicel one and a half times longer than broad; one short, transverse annellus; funicle with seven joints, the first two about as long as the pedicel, the others gradually shorter, the last two broader than long; club with three joints, slightly shorter than three preceding joints together. Thorax shagreened and slightly transversely striolate, dull. Pronotum narrower in front; mesonotum with strong parapsidal furrows; axillae large, almost meeting in the middle; scutellum strongly convex, separated from the axillae by deep furrows, more distinctly striolate near tip than at base; propodeum rather large with one median carina and two or three weak longitudinal carinae at sides; lateral furrows well marked; spiracles small, rounded. Marginal vein twice as long as the postmarginal; stigmal vein a little longer than

the postmarginal; discal ciliation short, the basal half almost without cilia. Hind legs strong, hind tibia with two spurs, the largest about twice as long as the other. Abdomen more finely shagreened at base than at tip, sessile, about as long as the thorax. Ovipositor not protruding.

*Male*.—Quite similar to the female in the form and structure of the body. But the body, antennae, and legs are entirely black with only the tarsi yellowish. Wings hyaline, scarcely infumate in middle. Antennae with pedicel more rounded, the funicle joints narrower. Mesonotum slightly more distinctly transversely striate. Abdomen smooth, shorter than the thorax.

Length, female 4.5 mm., male 3.5 mm.

Australia, New South Wales, Gosford, 1 female, 2 males, 7-XI-1910.

Bred from galls on Sheoak (*Casuarina* sp.).

***Lisseurytoma decorata*, new species (Ferrière)**

(Figs. 10 and 10a)

*Female*.—Body entirely black. Antennae black. Legs brown, the knees and tip of tibiae lighter, the tarsi yellowish. Wings with three transversal brown stripes, the first below the end of the submarginal vein, curved, the second in the middle, below the stigmal vein, thicker, and the third along the tip of the wing from a little beyond the end of the postmarginal vein.

Head transverse, narrowed behind the eyes; ocelli in a low triangle, the laterals closer to the eye margins than to the front ocellus. Vertex and frons finely shagreened; frontal furrow shallow. Antennae inserted a little above the lowest level of the eyes, with 13 joints, scape narrow, reaching the level of the front ocellus; pedicel pyriform, about one and a half times longer than broad; annellus narrower than pedicel, a little broader than long; funicle with seven joints, broadening gradually towards tip, the first three joints longer than broad, the second about as long as the pedicel, the fourth subquadrate, the last three transverse, the seventh more than twice as broad as long; club with three joints, short, scarcely longer than the three preceding joints together. Pronotum large, narrowed in front; mesonotum slightly longer than broad, finely transversely striate; parapsidal furrows deep; axillae meeting in the middle, with the furrows deep and crenulated, scutellum almost as long as the mesonotum, finely shagreened, more distinctly striate near tip; propodeum large, as long as the scutellum, smooth, with a few irregular striae near base and white cilia on the sides; spiracles rounded, very small. Wings with the marginal vein half as long as the submarginal; stigmal vein about as long as six-tenths of the marginal, the knob with two projections; postmarginal vein as long as eight-tenths of the marginal. Hind tibiae with two spurs, one much smaller than the other. Abdomen slightly narrower and shorter than the thorax, finely shagreened, almost smooth, the fifth joint the largest. Ovipositor not protruding.

Length 4.5-5 mm.

Australia, New South Wales, Euston, 2 females, 20-X-1920 (W. W. Froggatt)

*Type*.—British Museum (Natural History).

From galls on *Casuarina luehmanni*. With these insects is a small twig with seven galls of various sizes; they are bud galls, oval, more or less elongate, covered with curved bracteae; inside is a single elongate cell, in one of which was still a dried female with the pupal skin behind.

This species differs from *L. violaceitincta* Cam. by its entirely black body, the three black stripes on the wings, the longer postmarginal vein, and the absence of a median carina on the propodeum.

#### 14. Genus *Asparagobius* Mayr

*Asparagobius* Mayr, Verhandl. Zool.-Bot. Gesell. Wien, vol. 55, p. 549, 1905.

*A. braunsi* Mayr, the only species known, has been well described and figured. It is found in South Africa, where it forms galls on *Asparagus striatus*. According to Mayr, "the galls are formed on the buds of young twigs and are much similar to those of *Biorrhiza pallida* Ol. (*terminalis* F.) by their size and form. They are rounded, reaching a diameter of 48 mm., often a little flattened below . . . of brownish-green coloration, becoming brown-yellow with time." Inside, their structure is stronger than the galls of *Biorrhiza* and they have several cells.

A series of five females is in the British Museum, labeled "South Africa, Port Elizabeth, August, 1914, (J. L. Drage), ex galls on *Asparagus*." In the United States National Museum are three female paratypes labeled "Asp. braunsi G. Mayr, Type, Port Elizabeth," and one male from the Albany Museum labeled "Galls on *Asparagus*, Port Elizabeth, Sept., 1914, (J. L. Drege)."

#### 15. Genus *Brachyscelidiphaga* Ashmead

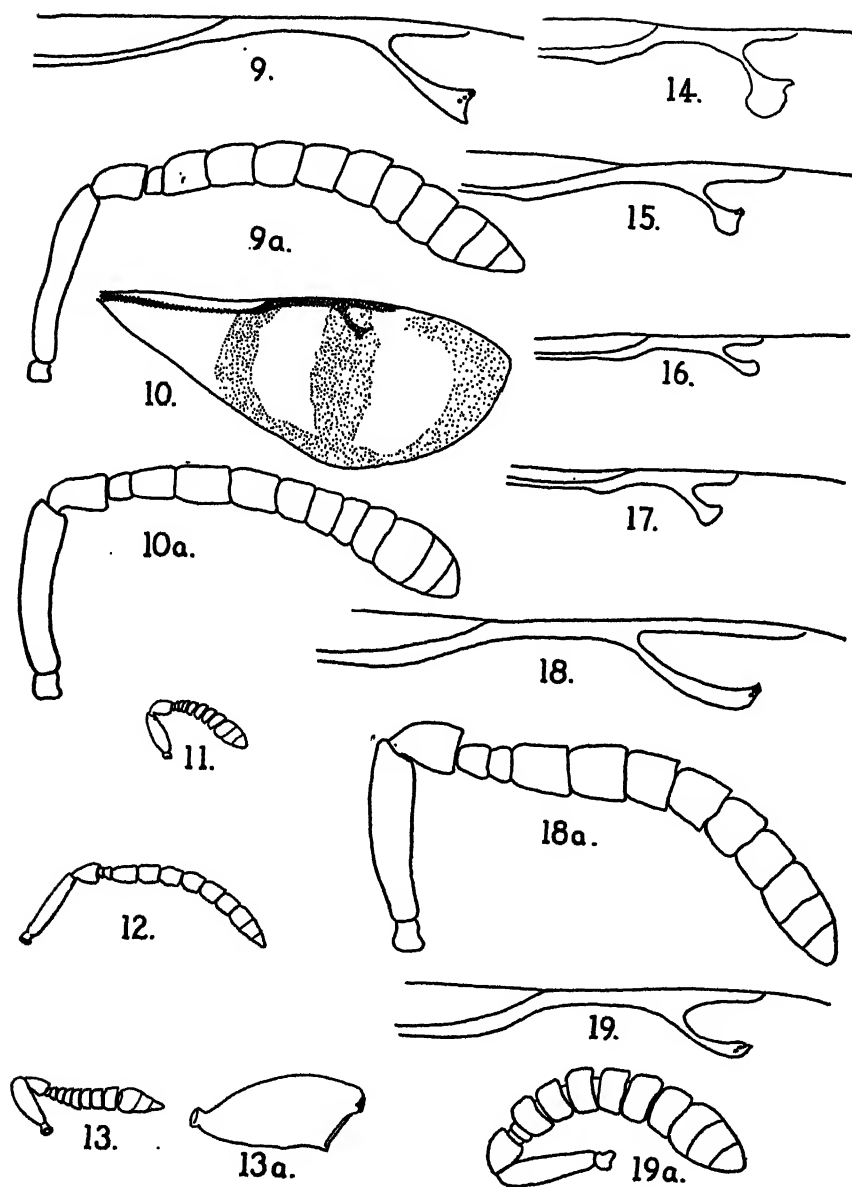
(Fig. 11)

*Brachyscelidiphaga* Ashmead, Proc. Linn. Soc. N. S. Wales, vol. 25, p. 343, 1900.

The genotype species, *B. flava* Ashm., is represented in the United States National Museum by a series of about 30 specimens including the types. These are said to have been reared at Sydney, New South Wales, from *Apiomorpha pileata* (Schröd.), a coccid which makes galls on *Eucalyptus*. Two additional species, both from Australia, have been

#### EXPLANATION OF FIGURES

- FIG. 9. *Lisseurytoma violaceitincta* Cameron. Venation of forewing.  
 FIG. 9a. *Lisseurytoma violaceitincta* Cameron. Antenna of female.  
 FIG. 10. *Lisseurytoma decorata* Ferrière. Forewing of female.  
 FIG. 10a. *Lisseurytoma decorata* Ferrière. Antenna of female.  
 FIG. 11. *Brachyscelidiphaga flava* Ashmead. Antenna of female.  
 FIG. 12. *Perilampomyia notatifrons* Girault. Antenna of female.  
 FIG. 13. *Systolomorpha thyridopterygis* Ashmead. Antenna of female.  
 FIG. 13a. *Systolomorpha thyridopterygis* Ashmead. Posterior femur of female.  
 FIG. 14. *Trichilogaster pendulae* Mayr. Venation of forewing.  
 FIG. 15. *Trichilogaster irilineata* (Cameron). Venation of forewing.  
 FIG. 16. *Trichilogaster arabicus* Ferrière. Venation of forewing.  
 FIG. 17. *Trichilogaster esculentus* Ferrière. Venation of forewing.  
 FIG. 18. *Trichilogasteriodes acaciae-discoloris* (Froggatt). Venation of forewing.  
 FIG. 18a. *Trichilogasteriodes acaciae-discoloris* (Froggatt). Antenna of female.  
 FIG. 19. *Decatomothorax flava* Ashmead. Venation of forewing.  
 FIG. 19a. *Decatomothorax flava* Ashmead. Antenna of female.



proposed in the genus by Girault (A New Habit in an Old Insect, *Homo Pudicus* and New Eurytomidae, p. 2, 1931), viz., *B. aeschlyi* and *B. masaccioni*. The last-named species is also said to have emerged from *Apiomorpha* (= *Brachyscelis*) on *Eucalyptus*.

Ashmead's description of the genotype is substantially correct except that the integument of head and dorsum of thorax is not smooth but distinctly finely reticulate-punctate. The head viewed from in front is wider than high; antennae inserted near middle of head; scape short, about twice as long as pedicel, subcompressed; scrobes not reaching anterior ocellus; clypeus not defined, the tentorial pits absent, anterior margin of clypeus incised; malar groove absent; ocelli in a low triangle; frons broad. Prothorax very short; parapsidal grooves sharply impressed, complete; axillae almost meeting; scutellum moderately convex, longer than broad, entirely immargined, slightly overhanging metanotum; propodeum short, with a delicate median longitudinal carina and a moderately deep longitudinal depression on each side between median line and spiracle; spiracle circular. Marginal and postmarginal veins subequal; stigmal vein about three-fourths as long as marginal, its knob rounded and moderately large. Legs normal; hind tibia apparently with only one spur. Abdomen sessile, not much longer than broad; ovipositor not exerted.

#### 16. Genus *Perilampomyia* Girault

(Fig. 12)

*Perilampomyia* Girault, Mem. Queensland Mus., vol. 5, p. 225, 1916.

Types of *P. notatifrons* Gir., the genotype species, are in the United States National Museum and were collected by G. Comper at Swan River, West Australia. A second species, *P. aeschlyi*, has been described by Girault (A New Habit in an Old Insect, *Homo Pudicus* and New Eurytomidae, p. 2, 1931) from Jandowae, Australia. Nothing is known of the biology of either species.

Girault's description of the genotype is slightly inaccurate, since the scutellum does not overhang the propodeum and the stigmal vein is not longer than the postmarginal but about equal to it. The antennae are inserted at middle of head, 13-segmented; scape slender, reaching level of vertex; two ring segments distinct; funicle 6-segmented, its first segment a little longer than broad and the sixth subquadrate; club 3-segmented. Head broader than high; eyes bare. Prothorax very short, rounded above and at sides; mesoscutum broader than long; parapsidal grooves moderately deep; scutellum longer than broad, margined only at apex; axillae not broadly separated; femoral furrow straight, narrow, and sharply impressed; stigmal knob moderately large and subrectangular; hind tibiae with only one spur. Abdomen rather robust, about as long as thorax and fully twice as long as broad; ovipositor not exerted.

#### 17. Genus *Systolomorpha* Ashmead

(Figs. 13 and 13a)

*Systolomorpha* Ashmead, Proc. Linn. Soc. N. S. Wales, vol. 25, p. 339, 1900.

*S. thyridopterygis* Ashm., the genotype, was placed by Ashmead in the subfamily Chalcodectinac of Cleonymidae and was considered to be

a parasite of a lepidopteron, *Thyridopteryx* sp., on *Eucalyptus*. Girault (Records, South Australian Museum, vol. 3, p. 318, 1927) placed the genus in Perilampidae and said that he had obtained many specimens of the genotype species from galls on *Casuarina quadrivalvis* and that they have no relation with *Thyridopteryx*. In 1929 (Trans. Roy. Soc. So. Austral., vol. 53, p. 316) he seems to consider this species not a gall maker, but a parasite of the gall-making coccid, *Cylindrococcus casuarinae*. A second species, *Systolomorpha nassau* Girault (Some Gem-like or Marvelous Inhabitants of the Woodland Heretofore Unknown and by Most Never Seen nor Dreamt of, Sydney, Australia, p. 3, 1925), is said to have come from a gall on *Casuarina* collected in Queensland, and a third species is described beyond.

The genus is characterized by having rather short, clavate, 13-segmented antennae inserted near middle of face; scape rather thick, subcompressed; pedicel a little less than half as long as scape; eight segments between pedicel and club, all distinctly broader than long, the first and second distinctly narrower than the others; club 3-segmented, a little thicker than funicle and about as long as three preceding segments combined; scrobes not deep and not reaching to anterior ocellus; eyes bare; ocelli in a low triangle; frons broad. Prothorax short; parapsidal grooves complete; axillae narrowly separated; scutellum convex, longer than broad, without a cross furrow and immargined except very weakly at apex; propodeum nearly smooth, without carinae but with a deep groove midway between spiracle and middle. Marginal and postmarginal veins subequal, not thickened; stigmal vein approximately three-fourths as long as marginal, thickened at apex but not forming a round knob. Anterior and posterior femora somewhat thickened, the latter with a broad, blunt, toothlike projection on its lower margin a little beyond the middle; hind tibia with two spurs. Abdomen sessile, compressed from the sides, about as long as the thorax, nearly circular in side view; ovipositor not exerted.

Male similar to the female except that the abdomen, as viewed from the side, is more than twice as long as thick.

Types of the genotype species are in the United States National Museum.

#### KEY TO SPECIES OF SYSTOLOMORPHA

1. Forewing with a distinct fuscous cloud; anterior legs, except coxae, clear yellow, 2  
Forewing without a distinct cloud; anterior and middle femora blackish  
basally, posterior pair entirely black..... *thyridopterygis* Ashmead
2. Posterior femur black except very narrowly along its ventral margin between  
the tooth and apex; middle femur blackish basally, *noblei*, new species (Gahan)  
Posterior femur black only on basal half; middle femur entirely yellow,  
*nassau* Girault

#### *Systolomorpha noblei*, new species (Gahan)

*Female*.—Length 2.5 mm. Black; antennal scape, pedicel and flagellum brownish black, the latter paler toward apex; coxae all black; all trochanters yellow; front femora and tibiae, middle femora apically, and middle and posterior tibiae pale yellow; middle femora basally and posterior femora entirely, except for a narrow yellow border on lower apical margin extending from the tooth to apex, black; all tarsi pale yellow at base, more or less fuscous beyond the first segment. Forewing



hyaline at base, fuscous on the disk from apical one-fourth of submarginal vein to apex of stigmal vein, the infuscation weaker adjacent to marginal vein and fading to subhyaline beyond apex of stigma; venation dark brown; posterior wing hyaline; mesopleuron with a narrow yellow line extending from below tegula to base of middle coxa. Abdomen mostly black but with base above more or less yellowish brown.

Head rather uniformly finely and densely reticulate-punctate; thorax similarly sculptured, the reticulation of median lobe of mesoscutum coarser than elsewhere; propodeum weakly lineated; abdomen weakly reticulated.

*Male*.—Like the female in all respects except in the shape of abdomen.

*Type locality*.—Gilgandra, New South Wales, Australia.

*Type*.—United States National Museum No. 58133.

Described from four females (1 holotype) and four males received from N. S. Noble and said to have been reared in August, 1935, from large spherical galls on *Casuarina luehmanni*. The species is named for the collector.

#### 18. Genus *Hemadas* Crawford

*Hemadas* Crawford, Can. Ent., vol. 41, p. 98, 1909.

*Parhabritys* Girault, Descriptiones Hymenopterorum Chalcidoidicarum Variorum cum Observationibus, vol. 5, p. 2, 1917.

This genus has as its genotype *Megorismus nubilipennis* Ashmead (Trans. American Ent. Soc., vol. 14, p. 192, 1887), which causes hard woody galls on the stems of *Vaccinium* in the eastern part of North America from Florida to Canada. A comprehensive account of the biology of this species, the only one thus far recorded in the genus, is given by McAlister and Anderson in the Journal of Economic Entomology (vol. 25, p. 1164, 1932). *Parhabritys* Girault has the same species as genotype.

Characters not given in the original description nor in the foregoing generic key are: Head viewed anteriorly, distinctly broader than high; antennae inserted a little above lower extremities of eyes; clypeus not emarginate; malar groove absent except for a short distance below eye; frons broad; ocelli in a low triangle, ocellocular line fully twice as long as greatest diameter of an ocellus. Pronotum short, rounded in front; mesonotum with complete but very shallow parapsidal grooves; axillae broadly separated; scutellum margined at apex, slightly overhanging metanotum; propodeum rather short, uniformly finely punctate and dull, without either a median carina or lateral folds but with shallow spiracular sulci. Postmarginal and stigmal veins subequal, each approximately two-thirds as long as marginal; stigmal vein only slightly thickened at apex, with a prominent stylus. Hind tibia with two spurs. Abdomen sessile, ovate, about as long as combined head and thorax, flattened dorsally; ovipositor not exerted.

#### 19. Genus *Coelocybella* Girault

*Coelocybella* Girault, Jour. Ent. and Zool., vol. 5, p. 53, 1913.

This genus is placed in the key on the basis of the description only. The only described species, *C. variegata* Girault, is said to have been

reared from unidentified galls at Brisbane, Australia (Mem. Queensland Mus., vol. 3, p. 306, 1915).

## 20. Genus *Trichilogaster* Mayr

*Trichilogaster* Mayr, Verhandl. Zool.-Bot. Gesell. Wien, vol. 55, p. 555, 1905.

*Epiperilampus* Girault, Can. Ent., vol. 45, p. 224, 1913.

This genus has been well characterized by Mayr, and several species have been described in it, all from Australia. All species, the biologies of which are known, form galls on the various species of *Acacia*. We are describing below two new species, one found in Central Australia, the other bred from galls on native acacias in the mountains of Southern Arabia, at a place where Asiatic, African, and Palearctic faunas meet and very far from the Australian region.

*Epiperilampus* was declared a synonym of *Trichilogaster* by Girault (Mem. Queensland Mus., vol. 5, p. 222, 1916) who, nevertheless, subsequently described several species under the suppressed generic name. Girault's species are known to us only through their short descriptions.

### KEY TO FEMALES OF SPECIES SEEN

1. Head and thorax black, except for some yellow markings on head and pronotum.....2  
Head and thorax mostly yellow.....3
2. Knob of stigmal vein large, its diameter equal to or exceeding length of its petiole; head black except for a reddish-yellow triangle with broad base on oral margin and its apex at base of antennae.....*pendulae* Mayr  
Knob of stigmal vein not large, its greatest diameter less than length of its petiole; spot in middle of face, frons along eye margins, vertex laterad of posterior ocelli, dorsal margin of pronotum, and frequently the lateral margins of median lobe of mesoscutum yellow or yellowish,  
*maideni* (Froggatt)
3. Mesonotum with three black longitudinal stripes, one down the middle and one along inner margin of each parapside; dorsum of thorax smooth and polished.....*trilineata* (Cameron)  
Mesonotum entirely or almost entirely yellow; dorsum of thorax usually transversely wrinkled (more or less smooth in *arabicus*).....4
4. Abdomen black, yellow only at base; propodeum black; wings hyaline; funicular segments subquadrate.....*arabicus*, new species (Ferrière)  
Abdomen yellow at base and broadly so at apex; propodeum usually yellow, rarely black; wings infuscated below apical end of submarginal vein; distal segments of funicle transverse.....5
5. Abdomen black below and with a broad transversal black band above; head, viewed from in front, broader than high...*acaciae-longifoliae* (Froggatt)...  
Abdomen yellow below, except at tip; black transversal band above narrow; head, viewed from in front, as high as broad, *esculentus*, new species (Ferrière)

### *Trichilogaster pendulae* Mayr

(Fig. 14)

*Trichilogaster pendulae* Mayr, Verhandl. Zool.-Bot. Gesell. Wien, vol. 55, p. 560, 1905.

Mayr has given a description of both sexes of this gall maker together with a description and figures of the gall. The galls develop from the axillary buds of *Acacia pendulae* in Australia.

The United States National Museum possesses a female and a male of this species from the Mayr collection labeled "G. Mayr. Type" and which undoubtedly are a part of the original type material.

**Trichilogaster maideni** (Froggatt)

*Cynips maideni* Froggatt, Proc. Linn. Soc. N. S. Wales, ser. 2, vol. 7, p. 155, 1892  
*Trichilogaster maideni* (Froggatt) Mayr, Verhandl. Zool.-Bot. Gesell. Wien, vol. 55, p. 558, 1905.

Originally described from Sydney, New South Wales, Australia, as making rough galls on twigs of *Acacia longifolia*.

The following specimens have been examined: In the British Museum, three females and one male from galls on twigs of *A. longifolia*, Ourimbah, New South Wales, October, 1925. In the United States National Museum, three females identified by Froggatt, from galls on *Acacia*, Botanic Garden, Sydney; one male from the Mayr collection, without locality label but identified by Mayr and undoubtedly constituting a part of the material from which he drew his description; eight females and eight males identified by Noble, causing elongate stem galls on *A. floribunda* and *A. implexa*, Sydney, November, 1936.

Mayr has given a good description of the species and also of the gall.

**Trichilogaster trilineata** (Cameron), new combination

(Fig. 15)

*Tepperella trilineata* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 37, p. 204, 1912.  
*Coelocybelloides mediolineatus* Girault, Mem. Queensland Mus., vol. 5, p. 225, 1915.  
New synonymy.

The type of this species, one female, is in the British Museum. Although the head is missing, it is easy to recognize that it belongs to the genus *Trichilogaster* Mayr. It is closely related to *T. acaciae-longifoliae*, from which it differs by the coloration of the thorax. The mesonotum has three longitudinal black stripes, one along the middle, the others along the parapsidal furrows, all these stripes meeting behind in the middle. The scutellum and axillae are entirely yellow; metanotum, except in the middle, and propodeum black; the anterior part of the pronotum and a spot on hind part of mesopleuron also black; abdomen yellow with a broad black cross band in the middle and narrower stripes at the end of the three last tergites. Legs yellow, except the middle coxae and a spot on the hind trochanters. Marginal and postmarginal veins thickened, stigmal vein with a large rounded knob.

The type is labeled "*Tepperella trimaculata* Cam., type. Tasmania, Launceston, Littler." This name "*trimaculata*" is found also at the end of the description, where the species is compared with *maculiscutis*, but the name at the head of the description is *trilineata* Cam. According to Cameron, the species has also been found in Melbourne in galls on *Acacia decurrens*. Morphological and biological studies of the species under the name *Tepperella trilineata* have been published by N. S. Noble (Proc. Linn. Soc. N. S. Wales, vol. 63, pp. 389-411, 1938; vol. 76, pp. 295, 296, 1941).

The types of *Coelocybelloides mediolineatus* Girault are in the United States National Museum and are not distinguishable in any way from *T. trilineata* as represented by a series of eight females and eight males in the same museum, reared by N. S. Noble at Sydney, New South Wales, from galls on *A. decurrens*.

**Trichilogaster arabicus**, new species (Ferrière)

(Fig. 16)

*Female*—Head and thorax orange yellow; occiput black; thorax with some brown spots on the front parts of the pronotum, the mesonotum, and the parapsides, on the sides of the axillae, and in the middle of the scutellum; postscutellum and propodeum black. Abdomen black, yellow at base. Antenna brown, lighter at tip, end of pedicel and the first annellus light yellow. Legs yellow, bases of coxae and of front and hind femora brownish. Wings hyaline, marginal and postmarginal veins mostly yellow.

Head a little broader than the thorax; vertex narrow anteroposteriorly; ocelli placed in a slight curve, the lateral ocelli at equal distance from the front ocellus and from the eyes. From in front, the head is rounded, the face broad, shagreened, dull; antennae inserted above the middle of the face; scrobal cavity narrow, reaching the front ocellus, with a thin carina between the antennae. Scape narrow, broadening slightly at tip; pedicel about twice as long as broad; first annellus small, quadrate, the second annellus not longer, but broader; first funicle joint shorter, but a little broader than the pedicel, slightly longer than broad; following joints shortening, the sixth subquadrate; club with three joints, almost as long as the three preceding joints together. Pronotum very short; mesonotum finely transversely striate; parapsidal furrows deep; scutellum finely shagreened, almost smooth; axillae distinctly separated; propodeum short, spiracles rather large, short oval. Wings large, discal cilia very short and sparse; marginal vein distinctly thickened, a little longer than the stigmal vein; stigmal vein with a rounded knob, as long as the postmarginal vein. Legs strong, with front and hind femora and hind tibiae slightly thickened. Abdomen shorter and narrower than the thorax, compressed from the sides. Ovipositor not protruding.

Length 1.8–2.8 mm.

Southwestern Arabia, West Aden Prot., Dhala, 4,800 feet, 64 females, 9–X–1937 (H. Scott and E. B. Britten).

Bred from galls on pods of thorny *Acacia*.

*Type*.—British Museum (Natural History).

This is the first species of *Trichilogaster* found outside Australia, and the question arises as to whether it has been imported. But Dr. Hugh Scott tells me that these thorny *Acacias* grow rather high in the mountainous regions of South Arabia and are indigenous.

This Arabian species differs from typical *Trichilogaster* spp. by the scrobal cavities which are longer and reach to the front ocellus, and by the axillae, which are distinctly but not broadly separated.

**Trichilogaster acaciae-longifoliae** (Froggatt)

*Cymips acaciae-longifoliae* Froggatt, Proc. Linn. Soc. N. S. Wales, ser. 2, vol. 7, p. 154, 1892.

*Trichilogaster longifoliae* (Froggatt) Mayr, Verhandl. Zool.-Bot. Gesell. Wien, vol. 55, p. 560, 1905.

*Epiperilampus xanthocephalus* Girault, Can. Ent., vol. 45, p. 224, 1913.

This species has been redescribed by Mayr from specimens sent to him by Froggatt. *Epiperilampus xanthocephalus* was placed in synonymy by Noble (Trans. Roy. Ent. Soc. London, vol. 90, p. 15, 1940).

*T. acaciae-longifoliae* was originally recorded as causing flower-bud galls on *Acacia longifolia*. According to Noble it also causes similar galls on *A. floribunda* and *A. sophorae*. In the British Museum are six females from flower gall on *Acacia longifolia*, Sydney, New South Wales, Australia, (W. W. Froggatt) November, 1923; and two females from Mingenew, Western Australia (R. E. Turner), October, 1935. The United States National Museum possesses one female from Rose Bay, Sydney, Australia, November, 1890, identified by G. Mayr; four females from galls on *A. longifolia*, Botanic Gardens, Sydney, November 15, 1911, identified by Froggatt; eight females and nine males from galls on *A. floribunda*, Sydney, November, 1936, identified by Noble.

The specimens from Turner's collection are somewhat darker, having brown spots on axillae and parapsides.

***Trichilogaster esculentus*, new species (Ferrière)**

(Fig. 17)

*Female*.—Body entirely orange yellow, except the occiput, the sides of the metanotum more or less, a transverse stripe in the middle of the abdomen and the last abdominal segment which are blackish. Antenna brown, scape and pedicel yellow. Legs entirely yellow. Wings hyaline, very slightly infuscated below the tip of the submarginal vein.

Head transverse, narrower than the thorax; ocelli in a very low triangle, the lateral ocelli somewhat closer to the eyes than to the front ocellus; seen from in front, the head a little broader than high, the eyes oval, the cheeks rounded. Antennae inserted above the middle of the face, level with the middle of the eyes; scape narrow, reaching just to the front ocellus; pedicel not quite twice as long as broad; two rather thick annelli; funicle with six joints, the first two subquadrate, the others broader than long; club with three joints, about as long as three preceding joints together. Thorax short, broad, rather smooth; pronotum very transverse; mesonotum with strong parapsidal furrows; axillae large, meeting in the middle at a small median, crenulated furrow; scutellum large, convex, with short longitudinal carinae near tip; propodeum short, with a thin median carina, and, on each side, two shorter carinae diverging posteriorly. Spiracles rather large, rounded. Wings with submarginal vein reaching almost to middle of anterior margin; marginal vein distinctly thickened, broadening slightly towards the stigmal vein, about three times longer than broad; stigmal vein a little shorter than marginal, broadly rounded at tip; postmarginal vein thick, scarcely longer than stigmal vein. Discal ciliation very short, sparse. Front and hind femora thickened, hind tibiae broadened and slightly flattened at tip, with two spurs. Abdomen short, oval, slightly narrower and distinctly shorter than the thorax, smooth, the fifth segment finely punctate; second segment the largest.

*Male*.—Body black; antennae dark brown, scape and base of pedicel black; legs yellow, base of femora brown. Morphologically similar to the female; antennae more elongate, all funicle joints longer than broad; thorax narrower and more elongate; mesonotum and scutellum finely striate; abdomen as long as the thorax.

Length, female and male, 3–3.2 mm.

Central Australia, near Alice Springs, five females, four males, October, 1934 (Professor J. B. Cleland).

From galls on *Acacia aneura*. These galls are said to be gathered and eaten by the natives.

*Type*.—British Museum (Natural History).

This species is related to *T. acaciae-longifoliae* Frogg., from which it differs mainly by the brown antennae, the shorter and smoother mesonotum, the longer marginal vein, and the less distinctly infumated wings.

The following species, all described by Girault from Australia, have not been seen by us but presumably all belong to *Trichilogaster*.

*Trichilogaster channingi* (Gir.), new combination.

Syn., *Epiperilampus channingi* Gir., Bul. Wis. Nat. Hist. Soc., vol. 11, p. 43, 1913.

*Trichilogaster significatus* (Gir.), new combination.

Syn., *Epiperilampus significatus* Gir., Mem. Queensland Mus., vol. 2, p. 301, 1913.

*Trichilogaster ater* (Gir.), new combination.

Syn., *Epiperilampus ater* Gir., Mem. Queensland Mus., vol. 3, p. 303, 1915.

*Trichilogaster adolphi* (Gir.), new combination.

Syn., *Epiperilampus adolphi* Gir., A New Habit in an Old Insect, Homo Pudicus and New Eurytomidae, p. 22, 1931.

*Trichilogaster atricarpus* (Gir.), new combination.

Syn., *Epiperilampus atricarpus* Gir., A New Habit in an Old Insect, Homo Pudicus and New Eurytomidae, p. 2, 1931.

*Trichilogaster atricarpus socratis* (Gir.), new combination.

Syn., *Epiperilampus atricarpus socratis* Gir., A New Habit in an Old Insect, Homo Pudicus and New Eurytomidae, p. 2, 1931.

*Cynips acaciae-discoloris* Froggatt is a closely related form which we have made the type of the new genus *Trichilogastroides*. *Epiperilampus diluiventris* Girault is transferred to the genus *Terobiella*. In a footnote attached to the original description of that species Girault indicated it as belonging to his genus *Melanosomella*, a synonym of *Terobiella*, and his description of the antennae leaves little question that it belongs in that genus.

## 21. Genus *Coelocybelloides* Girault

*Coelocybelloides* Girault, Mem. Queensland Mus., vol. 3, p. 307, 1915.

Placed in the generic key on the basis of the description. Except for the hyaline wings and slightly separated axillae, this seems to be very close to *Trichilogastroides*, new genus (Ferrière), described in this paper.

Two species (*aureus* and *pulchri-variegatus*) were originally included in the genus, with *aureus* cited as the genotype. Later, Girault (Mem. Queensland Mus., vol. 5, pp. 224, 225, 1916) described *C. bioculatus* and *mediolineatus*. *C. bioculatus* was based upon the same specimens as those used by Ashmead as the basis for his description of *Alloderma maculipennis* and is therefore a synonym of Ashmead's species. *C. mediolineatus*, types of which are in the United States National Museum, is identical with *Trichilogaster trilineata* (Carn.) as we have already stated. Four other species have been proposed in the genus by Girault, viz. *nigrisetae* and *pulchra* (Proc. and Trans. Roy. Soc. So. Austral., vol. 53, p. 317, 1929) and *atricarpus* and *flavivena* (A New Habit in an Old Insect, Homo Pudicus and New Eurytomidae, p. 2, 1931).

The generic description is not very complete, and the genus is therefore hard to evaluate. Judged by the fact that species of both *Alloderma* and *Trichilogaster* were assigned to it by Girault, it may possibly prove to be a synonym of one or the other of these genera.

22. Genus *Trichilogastroides*, new (Ferrière)

This genus is much similar to *Trichilogaster* in the form of body and antennae. It differs, however, greatly by the following characters:

Head and thorax smooth and shining, with long, scattered hairs. Eyes rounded or short oval, protruding. Antennae covered with rather long and strong ciliae. Pronotum without transverse carina. Parapsidal furrows almost straight. Wings distinctly longer than the body. Discal ciliation long and dense; marginal cilia short. Marginal vein elongate, narrow; stigmal vein long, curved, scarcely thickened at tip. Hind legs rather long, with long hairs. Abdomen oval, depressed above.

Genotype, the following species.

*Trichilogastroides acaciae-discoloris* (Froggatt), n. comb.

(Figs. 18 and 18a)

*Cynips acaciae-discoloris* Froggatt, Proc. Linn. Soc. N. S. Wales, ser. 2, vol. 7, p. 155, 1892.

*Female*.—Head and thorax orange yellow; stemmaticum and upper part of occiput black; pronotum with a rounded brown spot; propodeum and end of mesopleuron black. Abdomen black, brownish at base. Antennae black; scape, except tip, and pedicel orange yellow. Legs entirely yellow, except hind coxae brownish black. Wings infuscated, more strongly so on the anterior part below the marginal and post-marginal veins.

Head smooth with black cilia, sparse on frons, more dense on occiput. Eyes rounded, ocelli forming an obtuse triangle, the lateral ocelli a little closer to the front ocellus than to the eyes. Cheeks as long as half the diameter of the eye. Seen from in front, head broader than high, trapezoid. Clypeus small, excavate in the middle. Antennae inserted about level with the middle of the eyes; scape short, broadened at tip; pedicel scarcely longer than broad; anelli small, the first subquadrate, the second transverse; the six funicle joints short, the first a little longer than broad, the others subquadrate; club with three joints, about as long as two preceding joints together. Thorax smooth; mesonotum large, with deep parapsidal furrows, the middle lobe longer than its anterior breadth. Ciliation rather long and sparse on the sides of the pronotum, mesonotum and propodeum, along the hind margin of the pronotum, along the parapsidal and axillar furrows and at tip of scutellum. Axillae large, joining in the middle. Scutellum longer than broad. Propodeum with two median carinae which diverge behind, and also with lateral carinae; spiracles short oval. Wings with marginal vein a little longer than stigmal vein and as long as postmarginal vein. Legs strong; hind legs much longer than front legs, with large coxae and long black cilia on femora and tibiae. Abdomen almost as long as the thorax, oval, the first segment large, the other segments transverse; ovipositor not protruding.

Length 3.8 mm.

Redescribed from two specimens, one with the abdomen broken, which have been found lately in the cynipid collection of the British Museum under the name "*Cynips acaciae-discoloris* Frogg." They

bore no labels, except the No. 55, and are probably the types or cotypes of Froggatt.

According to Froggatt this species has been bred from galls on *Acacia discoloris* in Australia.

### 23. Genus *Decatomothorax* Ashmead

*Decatomothorax* Ashmead, Mem. Carnegie Mus., vol. 1, p. 273, 1904.

*Xaniheurytoma* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 36, p. 650, 1911. New synonymy.

The genotype is *D. gallicola* Ashm., described originally in the generic key to Tridymini. It was more fully described and figured by Froggatt (Agr. Gaz. N. S. Wales, vol. 16, p. 234, 1905) under the name of "The Thickset Chalcid." Froggatt's description is short and not quite correct. He described the antenna as formed of nine segments, but he did not count the annelli and considered the club as one segment although his figures show the presence of annelli and divisions in the club. In his book, "Forest Insects of Australia" (Sydney, p. 87, 1923), Froggatt gives again a short description of this species under the name of *Decatomothorax gallicola* Ashm.

The genus *Xaniheurytoma* was described by Cameron in the Eurytomidae and compared with *Xanthosoma* Ashm. (= *Eurytoma* Ill.). The genotype species, *X. flava* Cam., types of which are in the British Museum, is certainly congeneric with *Decatomothorax gallicola* Ashm.

It is quite likely that *Neorileyella* Girault (Mem. Queensland Mus., vol. 4, p. 272, 1913) is also a synonym of *Decatomothorax*. The type specimens of *D. gallicola* Ashm. bear a manuscript name label placed there by Girault, indicating his intention to describe them as a new species in *Neorileyella*. Also the description of *Neorileyella*, as far as it goes, seems to agree quite well with *Decatomothorax*, and at least one of the species which he included under the genus in his original description (viz. *N. hyalina*) is said to have come from a gall on the "Kurrajong" tree at Port Darwin, Australia. The Ashmead types were also from a gall on "Kurrajong." It is impossible to be sure of this synonymy in the absence of specimens or a more complete description of the genotype species, *N. fasciata* Gir.

*Chromosomeurytoma*, another genus described by Cameron (Proc. Linn. Soc. N. S. Wales, vol. 36, p. 648, 1911), was placed by its author near *Xaniheurytoma*. Types of the only species, *C. clavicornis*, obtained from galls on *Eucalyptus*, are in the British Museum and the species is a true eurytomid.

*Female*.—Head, viewed from in front, wider than high; malar space equal to approximately half the eye height, malar groove absent; clypeus with its anterior margin straight; tentorial pits small; eyes oval, and bare; antennal fossae about on a line with lower extremities of eyes; scrobal cavity rather deep, extending to anterior ocellus, not carinately margined, with a prominent compressed tubercle between bases of antennae; ocelli in a very low triangle, lateral ocelli about equally distant from anterior ocellus and eye margins. Head, viewed dorsally, strongly transverse, as wide as thorax; posterior orbits receding directly from eye margins; occiput straight, not at all concave and not margined. Antenna moderately clavate, 13-segmented; scape cylindrical, reaching



to anterior ocellus; pedicel about one and a half times as long as thick; two transverse ring segments; funicle distinctly thicker than pedicel, 6-segmented, the first and second segments about as long as broad, following segments successively shorter, the sixth segment about twice as broad as long; club 3-segmented, barely longer than two preceding segments combined, the two cross furrows distinct. Pronotum strongly transverse, rounded in front and at sides; mesoscutum broader than long; parapsidal grooves complete; axillae large, barely separated by a weak carina on the median line; scutellum convex, about as long as prescutum, carinately margined apically and slightly overhanging metanotum; propodeum with a weak median longitudinal carina, and another strong and slightly curved one on each side between spiracle and middle but much closer to middle than to the spiracle; propodeal spiracles rather large and nearly round, the spiracular grooves absent. Anterior and posterior femora slightly thickened; hind tibia a little broadened apically and with two distinct spurs. Forewings large, extending beyond apex of abdomen; marginal vein not thickened; stigmal vein strongly curved, about two-thirds as long as marginal, only slightly thickened at apex and without a distinct stylus; postmarginal vein a little shorter than stigmal; discal ciliation sparse, marginal fringe very short. Abdomen pointed ovate, as long as head and thorax combined, a little narrower than thorax, flattened or concave above, the first tergite incised medially; apices of ovipositor sheaths slightly exposed. Head, except within scrobal cavity, strongly sculptured with some umbilicate punctures on frons and vertex; pronotum posteriorly, mesoscutum entirely, dorsal part of axillae, and scutellum on basal two-thirds with strong umbilicate punctures, the remainder of these sclerites as well as the rest of thorax with rather dense rugulose sculpture; propodeum, except laterad of spiracles, nearly smooth; abdomen smooth.

*Male*.—Like the female except that abdomen is ellipsoidal and not longer than thorax.

### *Decatomothonax gallicola* Ashmead

*Decatomothonax gallicola* Ashmead, Mem. Carnegie Mus., vol. 1, p. 273, 1904.

*Female*.—Length 4 mm. Head, thorax, and propodeum yellow, the occiput brownish black, and the middle of scutellum as well as posterior part of mesoscutum more or less dark brownish. Antennae uniformly brownish yellow. Legs uniformly pale yellow. Wings hyaline, venation dark brownish. Abdomen mostly yellow, but with apical half of dorsum more or less blackish brown mixed with yellowish.

*Male*.—Length 2.5 mm. Similar to the female with the abdomen shorter and more extensively blackish above but with a bright yellow band at base.

Redescribed from four females and four males in the United States National Museum labeled "Kurrajong, Forbes, 1899." These specimens were the types of Ashmead's description and were undoubtedly sent to him by Froggatt from New South Wales, Australia. In his above-cited book on forest insects in Australia, Froggatt has given some interesting biological observations on this species which forms galls on young twigs of the Kurrajong, *Brachychiton populneum*.

**Decatomothonax flava** (Cameron), n. comb.

(Fig. 19 and 19a)

*Xantheurytoma flava* Cameron, Proc. Linn. Soc. N. S. Wales, vol. 36, p. 650, 1911.

Body orange yellow, the furrows between thoracic segments more or less brownish. Antenna of female brownish with scape and tip of pedicel yellow, of male entirely yellow. Abdomen of female reddish brown, of male more dark brown in the middle. Legs light yellow.

*Female*.—Head transverse; ocelli placed in a curve, the distance of lateral ocelli from the eyes and from the front ocellus equal. Antennae inserted a little above the lowest level of the eyes, with 13 joints; scape short; pedicel not much longer than broad; the two anelli transverse; all six funicle joints broader than long; club with three joints, as long as three preceding joints together. Thorax finely shagreened. Pronotum short; mesonotum broader than long, with deep parapsidal furrows, widely separated behind. Cameron says that the parapsidal furrows are rounded behind and meet in the middle, but he has taken the suture between mesonotum and axillae for the continuation of the parapsidal furrows. Axillae large, triangular, meeting in the middle. Scutellum strongly transversally convex, broader than long; middle of postscutellum and part of the short propodeum hidden below tip of scutellum. Propodeum with large short oval spiracles and slightly curved carinae on each side, between the spiracles and the middle. Wings large; marginal vein narrow, twice as long as stigmal vein, which is curved, thickened at base and about as long as postmarginal vein. Abdomen shorter than thorax, broadening behind and sharply narrowed at tip.

*Male*.—Similar to female; antennae longer, funicle joints more rectangular and more distinctly separated; abdomen narrower than the thorax.

Length 1.7–2 mm.

Redescribed from one female and one male, Cameron's types, in the British Museum, labeled: Australia, New South Wales, Richmond, 15–XII–1902; bred from galls in flowers of Kurrajong.

This species differs from Ashmead's species only by its much smaller size and its entirely yellow coloration with only the thoracic sutures darkened.

**24. Genus *Alloderma* Ashmead**

*Alloderma* Ashmead, Mem. Carnegie Mus., vol. 1, p. 273, 1904.

*Alloderma* was described in a generic key and *A. maculipennis* Ashm. named as the genotype. The only description of the species given by Ashmead was that in the generic key to Tridymini and no indication was given of the source of the specimens upon which it was based.

Generic characters taken from a female type are as follows: Head, view from in front broader than high; malar space equal to about three-fourths the eye height; eyes oval; malar groove effaced before reaching base of mandible; clypeus with its anterior margin straight; tentorial pits small; antennal fossae about on a line with lower extremities of eyes; scrobal cavity rather shallow and without limiting carinae; ocelli in a low triangle, the lateral ocelli fully as distant from eye margins as from

anterior ocellus. Head, viewed dorsally, strongly transverse, as broad as thorax; posterior orbits narrow and receding; occiput slightly concave, immargined. Antenna weakly clavate, 13-segmented; scape flattened beneath, a little thicker at apex than at base; pedicel about two and one-half times as long as broad; two ring segments, each a little longer than broad; first and second funicular segments about as long as broad, following progressively shorter; club 3-segmented, a little longer than two preceding segments combined, the two cross furrows distinct. Pronotum very short, rounded in front; mesoscutum broader than long with complete and moderately deep parapsidal grooves; axillae large, touching on median line; scutellum convex; a little shorter than prescutum, carinately margined apically and very slightly overhanging metanotum; propodeum rugose medially, without definite median carina but with incomplete lateral folds; spiracles moderately large and circular. Anterior and posterior femora slightly thickened; posterior tibiae with two spurs. Forewings large, extending beyond apex of abdomen by about the length of abdomen; marginal vein not thickened; stigmal vein straight, very nearly as long as marginal, its knob small, with a distinct stylus; postmarginal vein about equal to marginal; discal ciliation normal, marginal cilia short; disk of wing with a fuscous cloud. Abdomen ovoid, about as long and as broad as thorax, flattened dorsally, the first tergite incised medially; ovipositor shortly exerted. Face and cheeks rather weakly reticulately sculptured; frons and vertex densely ruguloso-punctate; whole dorsum of thorax densely ruguloso-punctate, a little more coarsely so than vertex, dull, the punctures obscured by irregular rugulae; abdomen smooth.

#### *Alloderma maculipennis* Ashmead

*Alloderma maculipennis* Ashmead, Mem. Carnegie Mus., vol. 1, p. 273, 1904.  
*Coelocybelloides bioculatus* Gir., Mem. Queensland Mus., vol. 5, p. 224, 1916.

*Female*.—Length 4 mm. Head, including antennae, brownish yellow, with a large spot on occiput black and a blackish streak below each eye. Thorax brownish yellow, with a spot on anterior margin of each axilla, the groove at base of scutellum, metanotum (except postscutellum), propodeum between spiracles, and whole of mesosternum black. Legs pale yellowish, except that posterior coxae are black basally and all tarsi more or less brownish. Anterior wing with a large fuscous cloud extending from the beginning of the curve in submarginal vein to apex of stigmal vein, the rest of wing hyaline or subhyaline. Abdomen black, with the ventral margins more or less broadly yellowish. There is no carina on scutellum such as described by Girault but instead a very faint median groove is present on one specimen only.

Redescribed from three females in the United States National Museum labeled "Turpentine Gum Galls, Sydney, 20-8-1898."

*Coelocybelloides bioculatus* Girault was described from the types of Ashmead's species.

# GROWTH RATE IN THE COCKROACH *PERIPLANETA AMERICANA* (LINN)<sup>1</sup>

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During a prolonged series of experiments with the so-called "intracellular symbionts" of the American cockroach, a thorough knowledge of the life history and rate of development of the host was found to be necessary. As there was little in the literature on the life-history of this roach, the necessary knowledge was obtained by careful observation and painstaking measurements of the animals in question. Some of the resulting data, not duplicated by the work of Gould and Deay ('38), is being published with the hope it may be of value to future workers.

As this study was made secondary to the "symbiont" work, only those phases of growth that had direct bearing on "symbiont" relationships were investigated, i. e.: numbers and duration of nymphal instars; correlation of weight and linear measurements to instar; and effect of heat and food on developmental rate.

The works of Rau ('24) and Klein ('33) were used as guides in beginning this study. Bodenheimer's ('33) summary was drawn upon in making certain correlations, and a comparison of the data here presented with that of Woodruff ('38, '39) on the German roach was attempted.

## MATERIALS AND METHODS

The original stock of roaches was collected at Pittsburg, Kansas, and Indianapolis, Indiana. The roaches were kept in the laboratory in a 20 gallon glass aquarium with a glass cover. About two-thirds the length of the aquarium was filled with a sheaf of thin boards spaced so the roaches could pass between them freely. The remainder of the space was kept open for food and water containers. As many as eight hundred roaches lived very comfortably in these quarters. The pen was cleaned periodically, usually when roaches or eggs were being taken out for experimental purposes.

Water was supplied continuously in a fountain bottle, i. e.: a 4 oz. bottle fitted with a 1-hole stopper holding a bent glass tube, inverted on a wire tripod so the tip of the glass tube was one-half inch from the floor. Food was placed in the cage once or twice weekly. Raw potatoes supplemented monthly with a little raw lean meat was most satis-

<sup>1</sup>The embryological studies and preliminary life history experiments were done at Indiana University (1933-36). Most of the specific data given in this paper, other than embryological, is the result of work done in connection with a study of the "Growth of the intracellular symbionts of the cockroaches" on a National Research Council Fellowship at Harvard University Biological Laboratories (1936-37). The work was completed and the paper prepared at Ohio University (1939-45).

<sup>2</sup>The author wishes to express his gratitude for the helpful criticisms received during the course of this work, especially from Professors C. T. Brues, Fernandus Payne, and A. C. Kinsey on the experimental work, and Professors G. W. Starcher and King Adamson on the mathematical calculations.

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factory, but Purina Dog Chow pellets gave excellent results. Unassorted table scraps, and all other fairly balanced diets tried were satisfactory, at least from the standpoint of fecundity.

Experimental animals were kept in glass culture dishes, the bottoms of which were covered with an appropriate size, low grade filter paper to facilitate cleaning. Water and food were supplied in Syracuse watch glasses as needed. Weighing and measuring were ordinarily done in a refrigerator room at 40 degrees F. at which temperature the animals were immobile. All weighing was done on analytical balances. Measurements on the first three instars were made with an eyepiece micrometer in a dissecting scope: later instars were measured with calipers.

#### THE LIFE CYCLE

*Eggs:* In *Periplaneta americana*, each ovary is made up of eight tapering ovarioles, with the anterior tips attached to the dorsal body wall and the posterior or basal ends opening into the oviduct. In a sexually active female, normally there are about 30 growing eggs in each ovariole ranging in size from 30 by 30  $\mu$  near the tip to 1.1 by 3.6 mm. at the base. One egg matures at the basal end of each ovariole every six or seven days. (Gould and Deay '38, Table II.) These mature eggs pass, one by one, into the oviduct and thence to the vagina where they are forced into the soft mass of plastic material which in turn is moulded into an ootheca by the ovipositor. The upper edge of the ootheca seems to be formed by crimping the edges of the sheet of plastic material together, much as the cover is fastened on a fruit pie.

The eggs in the oviduct are approximately 3.6 mm. long by 1.1 mm. thick, circular in cross-section, slightly concave on the ventral side, and a little smaller at the anterior end. They are pressed into the ootheca in two alternating rows, with the ventral side of the egg on the median line of the ootheca and the anterior end of the egg at the crimped edge of the ootheca. Eggs from the middle of the capsule are approximately 4 mm. long, 1.7 mm. thick and .85 mm. wide. Nearly one per cent of the eggs are placed wrong end up in the ootheca so they never emerge although development continues normally. Rotation of the egg on its longitudinal axis occurs infrequently and seems to have no permanent effect on development or hatching.

The normal number of eggs in the *P. americana* ootheca is sixteen, one from each ovariole. Occasionally a female consistently deposits only fifteen, or less, because of disease, degeneration, or other abnormality of one or more ovarioles. Insufficient or unbalanced diet causes a decrease in egg numbers. Gould and Deay ('38) report reduced numbers of eggs and imperfect capsules from old females. Imperfections with age were not found in the stock used in these experiments unless age was accompanied by ovariole degeneration or dietary deficiency. Specific diets of purified foods such as peptone or dextrose caused a decrease in frequency of ootheca production and a reduction of the number of eggs placed in the ootheca. In extreme cases, egg production was limited to one ootheca per month with six eggs each. Such eggs rarely hatched.

The length of time necessary for the completion of an ootheca depends on the condition of the female and on the temperature. Under

optimum conditions (good nutrition and 25 degrees C.) an ootheca is complete within eight to twelve hours after it is first visible and is dropped within another twelve hours. Under adverse conditions, the ootheca may be carried for four days or even longer (Rau '40). Ootheca forcibly removed from the female before they are complete invariably shrivel and fail to hatch.

*Incubation and eclosion:* In order to determine the optimum temperature for embryological development, groups of 25 ootheca were placed in incubators at each of several different temperatures with the results given in Table I. Later experiments showed no significant difference in rate of development and hatchability between 30° and 31° C., but higher temperatures are definitely detrimental. None hatched at 40° C.

Failure of eggs to hatch under normal conditions is usually due to either improperly sealed oothecae, which allows the eggs to dry, or to mould or bacterial infection. Of several thousand oothecae studied, none were definitely proved to be infertile (Contrast Gould and Deay '38). Of 60 virgin mature females kept under observation for two months, none produced any oothecae.

TABLE I  
EFFECT OF TEMPERATURE ON INCUBATION

Temperature	Days Incubation	Per Cent Hatch
21 degrees C.....	54-60	70
28 degrees C.....	32-34	80
30 degrees C.....	29-30	83
33 degrees C.....	31-33	81
36 degrees C.....	32-34	65

At constant temperature (30° C.), and reasonable humidity, no seasonal variation in hatching time was noted in nearly three years of continuous embryological studies. The seasonal fluctuations in hatching time reported by Gould and Deay ('38) are, therefore, rather difficult to interpret.

Eclosion, or hatching, occurs when all embryos are developed enough to exert sufficient pressure to open the ootheca. As soon as the cement on the lips of the ootheca is broken all nymphs wriggle out, moulting their embryonic skin as they do so. If one or two fail to emerge when the others do, they perish, as they are not able to force the ootheca open again. Eclosion may be brought about as much as three days prematurely by manually opening the capsule, but such premature nymphs are rather frail and sometimes do not survive.

Attempts to rear embryos out of the ootheca were not generally successful, probably because of injuries inflicted on the embryos during the process of removing them from the ootheca. However, a few animals removed from the oothecae, completed the last one-third of their embryonic development in test tubes of sterile agar. These hatched at their regular time and behaved in a normal manner.

*Nymphal instars and moulting:* The newly emerged nymphs from each of five ootheca were placed in separate glass bowls. These were fed all

they could eat and were transferred to successively larger bowls as they became overcrowded. They were examined twice daily, and all moults were recorded. The newly-moulted animals of each group were placed in a new bowl, so that each bowl had individuals of the same nymphal stage. (A supplementary series of 10 animals of each instar, selected from the stock culture, was checked concurrently with the main series.) To facilitate identifying individual roaches, those of the fourth instar and older were marked by punching various combinations of smooth round holes through the edges of the nota with a fine forceps-punch. After the animals moulted, the marks remained as scars.

The results of this time study are given in fig. 1. Each circle represents the mean time of moulting of five individuals. The normal moulting time was determined arbitrarily as the point of intersection of

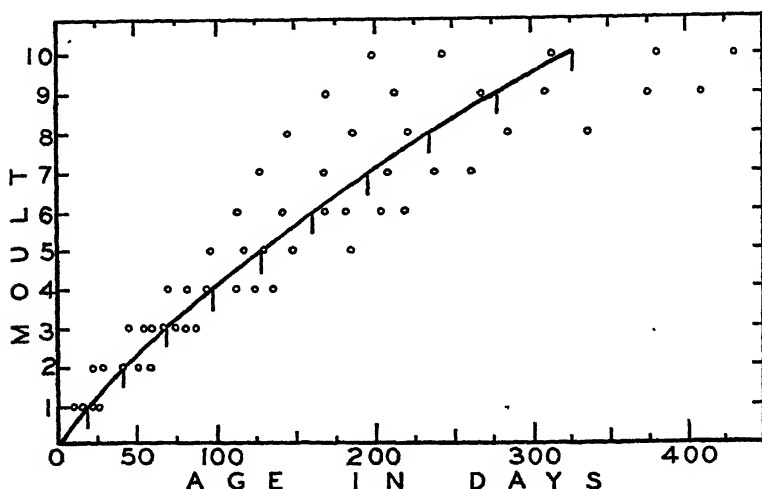


FIG. 1. The time of moulting in *Periplaneta americana*. Moulting time was noted for approximately 75 animals from the time they hatched until they were sexually mature. Each circle on the graph represents five individual moults of nearly the same age. The ordinate indicates the number of times the roaches in question had moulted; the abscissa gives the age of those animals in days. An even curve was drawn approximately through the mean time for each moult. The point of intersection of this curve with the line on which the moult in question was recorded indicates the "normal" time of moult. The duration of the nymphal instars in the succeeding graphs are based on these results.

a smooth curve drawn approximately through the mean date for each moult and the line on which the dates were plotted. The duration of the successive instars thus established are 18, 24, 26, 29, 30, 33, 38, 40, 43, and 50 days. This shows, as in individual cases, successively longer growth periods for succeeding instars. In general, a roach that moulted early one time would continue moulting early on succeeding times, thus reaching the adult stage much younger than the average, and those that remained in one stage longer than usual repeatedly moulted late. Age variation in all groups observed, followed this same schedule very closely. In three cases it was determined definitely that certain indi-

viduals grew oversize in instar III, and after they moulted, they conformed closely in proportions to animals of instar V. Two others, in the same way, omitted instar VI, but in no case was the series shortened by more than one instar. In one case, a seventh instar male moulted ten days after reaching that stage without having increased appreciably

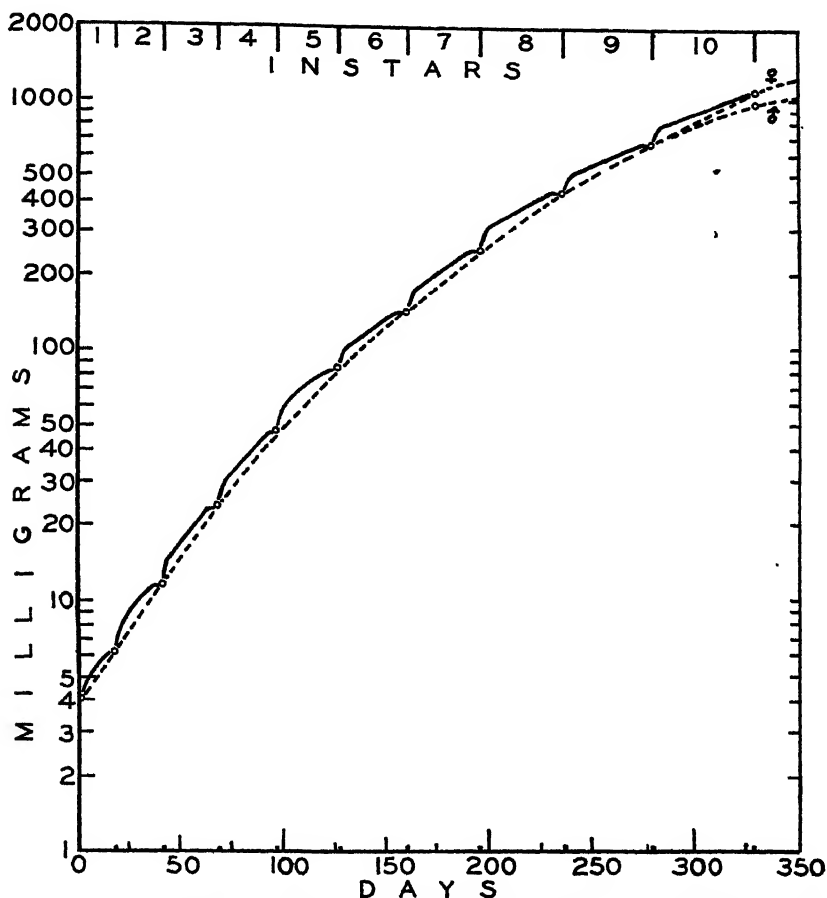


FIG. 2. Increase in weight in *Periplaneta americana*. The weight in milligrams, is plotted on a semi-logarithmic scale against the "normal" duration of instars. The dotted line represents the general trend of development. Solid lines show the actual weight of an average individual. In this and succeeding graphs where there are two trends in late nymphal and adult stages, the upper line indicates the female characteristic and the lower line represents the male.

in size, which may indicate that under certain conditions superfluous moulting may occur. The finding of ten nymphal instars confirms the work of Fischer ('28).

Another series reared in the incubator at 30° C. went through corresponding moults as far as the eighth instar at which time the experiment was discontinued. Early moults were speeded up considerably



at this temperature, later moults were affected less, e. g.: some individuals moulted successively at 8, 23, 39, and 58 days, while the youngest fifth instar at room temperature was 70 days old. There are, of course, some individuals at any temperature that do not moult when they should. Those seem to be, for the most part, roaches with low vitality, possibly because of disease, poor nutrition, or over-infestation with parasites. These slow-moulting individuals were subject, much more than others, to unsuccessful moults. Sometimes they died half way out of the old skin, sometimes they were eaten by their more vigorous cage mates, and sometimes they emerged badly misshapen. It is

TABLE II  
CHARACTERISTICS OF *Periplaneta americana*

Weights (in milligrams) and measurements (in millimeters) were taken as soon as the new chitin hardened after the moult and before the roach was allowed anything to eat. The median and extremes are listed in each case.

Instar	Age (in days)	Weight	Body Length	Tibia Length	Head Length	Pronotum Width	Abdomen Width	Antennae Length
I	Just hatched	4.5 4-5	4.4 4.1-4.6	1.28 1.25-1.3	1.35 1.3-1.4	1.7 1.6-1.8	1.9 1.8-2.0	6.5 5.8-7
II	18 10-30	6.4 6.0-6.8	5.2 4.5-5.4	1.7 1.6-1.8	1.65 1.6-1.7	2.1 2.0-2.15	2.5 2.3-2.7	9.5 9.0-10.6
III	42 20-60	11.5 10.2-12	6.5 6.0-7.0	2.04 2.-2.1	2.0 1.9-2.1	2.5 2.3-2.7	3 2.7-3.2	11.2 10.5-12
IV	68 45-90	24 21-30	8.6 8.0-9.0	2.5 2.4-2.6	2.25 2.1-2.4	3.2 3.0-3.3	3.4 3.1-3.7	13.5 12-15
V	97 70-160	46 35-55	10.8 9-12	3.15 3.0-3.2	2.58 2.5-2.6	3.8 3.4-4	4.2 4.0-4.5	16.2 15-18
VI	127 90-190	88 70-102	13.1 11-15	4.0 3.9-4.1	3.2 3-3.3	4.8 4.5-5.0	5.2 5.0-5.6	21 20-24
VII	160 110-210	140 106-160	16 15-17	5.2 5.0-5.4	3.9 3.8-4.2	5.8 5.5-6.2	6.5 6.0-7.0	26 24-27
VIII	195 125-265	250 190-280	19 18-21	6.6 6.2-7.0	4.5 4.4-4.7	7.0 6.8-7.5	8.3 8-9	31 29-37
IX	235 140-340	420 325-520	23 21-25	8.05 7.8-8.5	5.3 5.2-5.5	8.1 8.0-8.5	10 9.5-10.5	38 37-40
X	278 160-450	650 500-750	28 24-30	9.8 9.0-10	6.0 5.8-6.2	10 9.0-10.5	11.6 11-12	45 40-49
XI F	328 190-520	1090 1020-1210	35 33-37	12.2 12-13	6.5 6.3-7.0	10.5 10-11	13 12-14	54 49-59
XI M	328 190-520	980 910-1050	34 33-36	12.2 12-12.5	6.6 6.5-7.5	10 9.5-10.5	11 10.5-11.5	54 49-59

doubtful if many of these extremely tardy individuals would ever reach maturity in nature.

Part of the individuals from the experiment described above, and a considerable number from other series, were weighed and measured in order to get some relationship between size and instar, and to determine actual growth rate. Between ten and twenty newly-moulted, unfed individuals of each instar were weighed and measured, as were also a considerable number of individuals later in each stage. The major results are summarized in Table II, and graphed as stated below.

The weight of roaches, according to instars, is plotted in fig. 2, on a semilogarithmic scale. The dotted line shows the general growth of an "average animal," the solid lines represent more nearly the actual weight of any individual. The weight of an individual changes rapidly at moulting time, because the animal eats nothing for at least a day before moulting, then eats all it can a few hours after the moult. No significant difference in weight between the sexes was detected until the last nymphal instar.

Total body length is plotted in fig. 3. The general growth rate appears to be quite regular except for a slight acceleration in the third

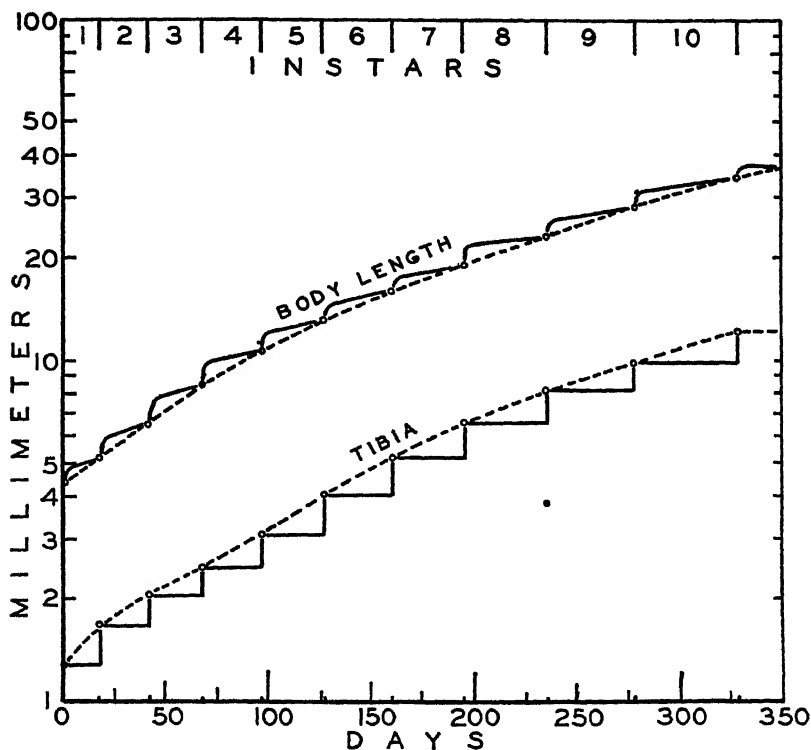


FIG. 3. Total body length and metathoracic tibial length of *Periplaneta americana*. The body length was measured from the tip of the forehead to the tip of the abdomen (exclusive of the cerci). The tibial length was taken as the actual length of the tibia without the spines. Solid lines show the actual individual increase.

and fourth instar. The sudden increase following the moult is due to rapid lengthening of the abdomen during the first few feedings. Continuous increase in length between moults is accounted for entirely by expansion of intersegmental membranes.

In contrast to weight and length, which have more or less continuous change, all solidly chitinized structures have discontinuous growth,

increasing in size appreciably only at the time of moult. Of such structures, measurements were taken on the legs, antennae, abdominal sclerites, and palpi. The length of the metathoracic tibia is plotted in fig. 3. This structure is so constant between moults, has so little individual variation, and is so easily measured that it can be used as an almost certain index of the degree of development, if it is not a regenerated structure. Regenerating appendages apparently follow the same pattern as described by Woodruff ('37) for *Blattella germanica*.

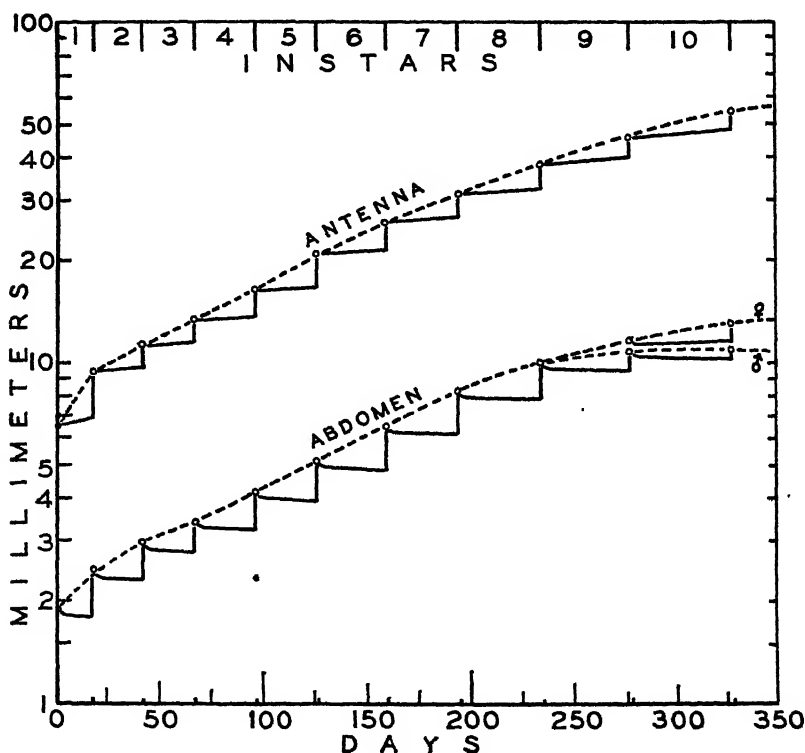


FIG. 4. Width of the abdomen and length of antenna of *Periplaneta americana*. The measurement was taken across the widest part of the abdomen (4th segment). The narrowing of the abdomen after the moult was determined by close observation on individuals for the entire period between moults. Antennae length was measured only on individuals with both antennae the same length and apparently normal for the instar in question.

The antennae (fig. 4) and the cerci, increase definitely in length at the moult, but continue slight elongation (by stretching of inter-segmental areas) between moults. The antenna regularly increases near 50 per cent of its original length at the time of the first moult, then maintains a nearly constant rate of approximately 20 per cent increases at each succeeding moult. It is probably rather uncommon for a roach to go through all ten instars in captivity without breaking off one or both antennae at least once, and regenerated antennae are measurably

smaller and shorter than normal for at least two instars following the break. Because of so many questionable cases, antennal length has not been regarded seriously in this study. The cerci are so small, and hard to measure, that sufficient measurements were not taken to include in the summary table.

The width of the pronotum and the length of the head (fig. 5) do not, generally, offer good characteristics for determining stadia because of the low rate of increase, at times resulting in an overlapping of measurements of individuals in two successive moults. The head length shows the greatest irregularity of increase of any structures studied. This irregularity may be more apparent than real, because a slight variation in the angle of measurement makes a significant difference in the results, and with use of only live roaches, this variation was not corrected.

TABLE III

PROGRESSION FACTORS FOR CHARACTERISTICS OF *Periplaneta americana* CALCULATED FROM THE AVERAGE MEASUREMENTS GIVEN IN TABLE II

Moult between Instars	Weight	Body Length	Metath. Tibia	Head Length	Prothorax Width	Abdominal Width	Antennae Length
1-2.....	1.42	1.18	1.325	1.22	1.23	1.31	1.46
2-3.....	1.8	1.25	1.2	1.21	1.19	1.2	1.18
3-4.....	2.18	1.32	1.22	1.12	1.28	1.13	1.2
4-5.....	1.92	1.25	1.22	1.13	1.19	1.2	1.20
5-6.....	1.92	1.21	1.31	1.25	1.26	1.27	1.29
6-7.....	1.52	1.22	1.3	1.25	1.205	1.25	1.21
7-8.....	1.78	1.19	1.27	1.25	1.215	1.29	1.21
8-9.....	1.76	1.21	1.22	1.20	1.16	1.19	1.225
9-10.....	1.47	1.19	1.21	1.11	1.23	1.12	1.18
10-11..... F	1.68	1.27	1.26	1.1	1.05	1.16	1.20
M	1.5	1.16	1.25	1.1	1.00	.98	1.20

The abdomen, although fairly constant in the newly moulted animal, varies considerably with feeding conditions, in general becoming narrower, thicker, and longer as growth proceeds between moults (Table II, and fig. 4). There is definitely a differential development in this characteristic, the abdomen is proportionately much wider during the second and third instars than at later times. Males can be differentiated from the females in the adult stage by the more slender, tapered abdomen and the longer wings. The sexes can be differentiated even in the first, instar by the division of the last abdominal sternite in the female, as described by Gould and Deay ('38).

*Analysis of growth rate:* Various analyses of the data here presented have been attempted, with only nominal correlation with previously published analyses of growth rates in all cases.

Dyar's rule, as stated and interpreted by Przibram ('12) and Bodenheimer ('33), has no real merit in this case. The progression factors for the characteristics under consideration are given in Table III. These progression factors (P. F.) are calculated by dividing the measurement immediately following the moult by the similar measurement following the previous moult. From the second to the fifth moult, the P. F. for

weight approaches the standard derived by Dyar: for the other moults the factor is considerably low. This would indicate superfluous moults if Dyar's rule has a fundamental basis. The progression factors for some of the linear measurements (body length and pronotal width) show something of the same trend as for weight. The peak development for the metathoracic tibial length and head length, however, is shifted to the fifth, sixth, and seventh moults. These trends are graphically shown in figs. 2 to 5. Weight, body length, and prothoracic width have a rather regular change in the decrease of their progression rates, producing an even curve depressed on the upper end as pointed out by Gaines and Campbell ('35). Weight, especially, shows a tendency toward a sigmoid curve. When the curve is extended back approaching zero weight, the sigmoid nature of the curve is quite pronounced. Abdominal width,

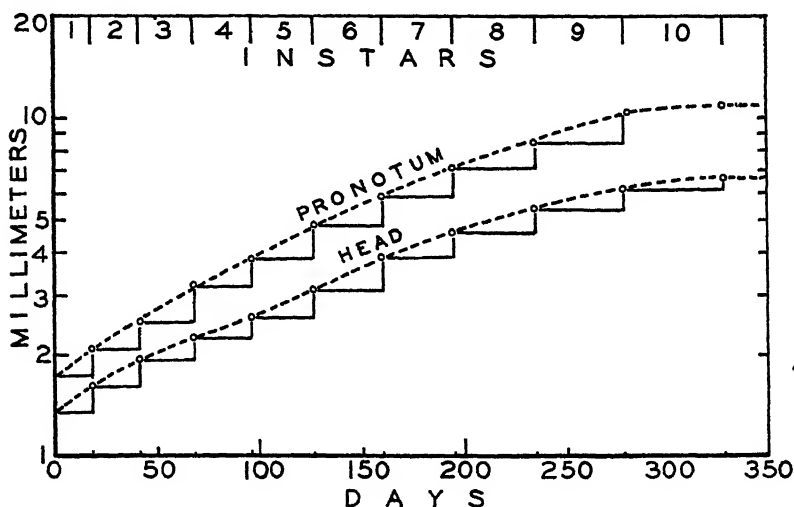


FIG. 5. Width of the pronotum and length of the head. The pronotal width was taken as the widest point, edge to edge. The head was measured with calipers from the tip of the crown to the center of the notch of the labrum.

metathoracic tibial length and head length do not have the same regular pattern of development as do the other characteristics listed, as can be seen by the depression in the curve for moults 4, 5, and 6. This same depression of the growth curve occurs for antennal length, but to a less marked extent. Antennal length shows the additional peculiarity of an exceedingly great increase at the onset of Instar II. Abdominal width of the male and prothoracic width of both sexes in *P. americana*, as Woodruff ('39) found for the prothorax of *Blattella germanica*, nearly reached their maximum size at the beginning of the last nymphal instar. These variations in pitch and regularity of curves reinforces the opinion advanced by Woodruff ('39) that each part of the body has its own rate of development, and adds the probability that the rate of development may be irregular, i. e.: differential development for some structures and regular for others.

An attempt at applying Woodruff's ('38, '39) equations to these growth curves met with moderate success. He found that for the German roach, the general equation for a parabola gave a fair fit for the observed growth curve, but that the form of logarithmic curve expressed by the equation  $\log W = a + bt + c \log(t+1)$ , simplified to  $\log W = bt + c \log t$  corresponded to the observed growth curves much better. In the equations  $W$  is the measured value,  $t$  is the age in days,

TABLE IV  
CONSTANTS DETERMINED FOR DIFFERENT METHODS

	CONSTANTS		
	a	b	c
1. $\log w = a + bt + ct^2$ start $t = 0$ at eclosion	1.65718	.018538	.000007508
2. $\log w = a + bt + c \log t$ start $t = 0$ at oviposition	4.41124	.009929	1.33517
3. $\log w = a + bt + c \log t$ start $t = 1$ at eclosion	1.1945	.014107	.2558
4. $\log w = a + bt + c \log t$ start $t = 50$ at occlusion	7.409	.004872	2.1214

TABLE V  
COMPARISON OF WEIGHT INCREASE AS DETERMINED BY DIFFERENT METHODS

METHOD	INSTAR										ADULT
	1	2	3	4	5	6	7	8	9	10	
Observed	4	6.4	11.5	24	46	88	140	250	420	650	1090
1.....	5.24	7.34	11	19	34	62.5	123	259	619	1620	5680
2.....	3.70	6.67	12.3	22.5	41	71	123	214	402	721	1390
3.....	4.25	8.91	15.4	25	42	68	115	200	367	704	1490
4.....	3.1	5.9	14	24	49	85	138	234	403	651	1101

and  $a$ ,  $b$ , and  $c$  are constants. When the constants  $a$ ,  $b$ , and  $c$  were determined by the method of least squares for the equation for a parabola,

$$\log W = a + bt + ct^2 \quad (1)$$

beginning with  $W=4$  and  $t=0$ , at eclosion, a very different curve was obtained than the one from observed data. With the derived constants (Table V), there is no factor to reduce the curve at its upper end, so it proceeds off the scale, with a value for  $W$  near maturity much higher than observed (Method 1, Table IV).

Considering the equation for the logarithmic curve recommended by Woodruff ('38),

$$\log W = a + bt + c \log t \quad (2)$$

it was found that only by starting with a real number greater than 1 could the observed growth curve be closely approximated. When the equation was set up with  $t=0$  at oviposition, there was a fair approximation of the actual growth curve up to the ninth instar (Method 2, Table IV).

TABLE VI

COMPARISON OF THE VALUE OF THE MEASURED CHARACTERISTICS AS OBSERVED (a) AND AS CALCULATED (c) BY THE EQUATION LOG

$w = a + bt + c \log t$  beginning with  $t = 50$  days at eclosion

INSTAR	BODY STRUCTURE						
	Weight	Body Length	Tibia Length	Head Length	Pronotum Width	Abdomen Width	Antenna Length
I	o	4.0	4.4	1.3	1.35	1.7	1.9
	c	3.1	3.8	1.02	1.3	1.8	1.83
II	o	6.4	5.2	1.7	1.65	2.1	2.5
	c	5.9	5.3	1.6	1.6	2.15	2.34
III	o	11.5	6.5	2.04	2.0	2.5	3
	c	13	6.8	2.2	1.7	2.63	2.98
IV	o	24	8.6	2.5	2.25	3.2	3.4
	c	24.3	8.5	2.64	1.95	3.17	3.71
V	o	46	10.5	3.1	2.58	3.8	4.2
	c	49	10.6	3.3	2.8	3.81	4.55
VI	o	88	13.1	4.	3.2	4.8	5.2
	c	85	13	4.08	3.25	4.6	5.47
VII	o	140	16	5.2	3.9	5.8	6.5
	c	138	15.6	5.03	3.8	5.4	6.56
VIII	o	250	19	6.6	4.5	7.0	8.3
	c	234	18.9	6.2	4.36	6.35	7.8
IX	o	420	23	8.05	5.3	8.2	10.
	c	403	23	7.7	5.1	7.43	9.34
X	o	650	28	9.8	6.0	10	11.6
	c	651	28.1	9.6	5.83	9.51	11.5
Adult	o	1090	35	12.2	6.5	10.5	13
	c	1100	35.2	12.6	6.8	11.8	13.4
Sy		7.8	.23	.026	.021	.53	.32
Constants of Progression:							
a	-7.409	-1.1265	-2.3587	-2.1075	-1.15532	-2.08634	-2.4652
b	.004872	.002682	.003133	.001452	.003271	.0020346	.0000065
c	2.1214	.6186	.62016	.58605	.403023	.66186	1.0788

Starting with  $t=1$  at eclosion (Method 3, Table IV) the calculated curve is fair up to the tenth instar, but here again, the "depressor" is not active enough as  $t$  and  $W$  increase.

If, however, eclosion time is considered as 50 days following oviposition, and subsequent moulting times are calculated from that, a very close fit is obtained for weight (Table IV, Method 4), and for several other characteristics (Table VI), indicating that here, in general, growth

rates follow the same pattern established by Woodruff ('38 and '39) for *Blatella germanica*, although differential development is not acknowledged by such mathematical equations, and any irregularities must necessarily increase the calculated deviation. For all the structures here considered, the calculated curve so closely fits the observed curve that no attempt is made to compare the two curves graphically.

Woodruff's ('38) suggestion that the constant  $a$  may be omitted and thus modify the equation to

$$\log W = bt + c \log t$$

is not possible for *Periplaneta americana* because  $a$  in no case approaches unity and such omission drastically modifies the position of the curve on the vertical scale.

We may well conclude that the growth rate of the animal in question, and possibly of all Blattidae, in general follows a logarithmic curve represented by the equation  $\log W = a + bt + c \log (t+x)$  where  $x$  equals the approximate number of days between oviposition and eclosion. The variations in the curves, however, stress the specific growth behavior of different structures on the same individual, and mean that more constants must be used in any equation to compensate for the irregularities involved.

It is impossible to make such calculations as those presented in this discussion without questioning what factors in the animal correspond to the "constants of progression" used in our mathematical calculations.

Detailed work on the fat bodies of the roaches used in this study further disproves (Abercrombie, '36) the generalization advanced by Sztern ('14) and adopted by Bodenheimer ('33) that a doubling of cells accompanied each moult. The bacteriocytes (symbiont-filled cells within the fat bodies) were carefully counted and their volumes calculated for a large series of roaches. At the time of hatching, the average number of bacteriocytes per roach is approximately 1700, and the final number, in an adult female is approximately 100,000, or an average increment of only 1.58. An average increment of 2 would give a final number of 17,380,000, or about 173 times the actual figure. The volume of these cells, however, increased at a much more rapid rate, maintaining the original ratio of bacteriocyte volume to total body weight, by increase in size of individual cells. The details of this work will be released in the near future.

#### EFFECT OF DIET ON GROWTH

A few feeding experiments indicate that the American roach can live for long periods of time on very insufficient diets. Of five individuals (of instars 4, 6, and 9) kept in glass bowls with distilled water and acid-washed filter-paper, the survival periods were 12, 14, 33, 76, and 101 days. One of five tenth instar females, fed only dextrose, moulted successfully after 60 days, and produced five egg capsules in the following four months. The eggs in two of these capsules hatched and a normal proportion of the young lived for five months, with dextrose, filter paper and tap water as their only source of nourishment, but none of these had reached the stage of development necessary for the second moult before the experiment was terminated. Roaches fed on peptone



or gelatine died in about the same length of time as did those that had agar or filter paper only.

Several groups were hatched aseptically (after sterilization of the ootheca in equal parts 1-500 mercuric chloride and 95 per cent alcohol for 10 min.), and were kept in large test tubes on sterile bacteriological media (nutrient agar with whole wheat, yeast, or blood added). A few were kept sterile as long as 110 days. Of these, 18 moulted twice, and only one moulted three times. They were considerably smaller than normal animals in the same stage. Animals with the same food plus their normal intestinal flora grew normally.

Those animals without food or with pure proteins lived only until the supply of fat stored in their fat bodies was exhausted. Then they starved to death—with plenty of proteins in the gut lumen, and masses of crystals (of a protein nature) in their fat bodies. On the other hand, those that had only purified carbohydrates (dextrose, dextrin, lactose, galactose and mannite) lived very well and increased in weight (by deposition of fat). Seventeen out of twenty-five of the animals supplied only with carbohydrates lived 300 days, at which time they were killed and examined. All had rich fat stores, and none had any protein crystals in the fat bodies. These, however, failed to grow or reproduce normally because of lack of proteins or minerals, or vitamins, or combinations of these.

The feeding experiments would indicate the following points concerning the physiology of *Periplaneta americana*.

1. This roach either has little powers of deaminotization, or it has poor facilities for eliminating protein wastes.

2. This roach cannot build proteins, or growth vitamins, for itself, but intestinal bacteria may produce enough of these substances from simple foods to keep the animal alive.

3. The crystals in the fat body may represent accumulations of protein waste that are either eliminated or utilized when protein food is limited.

Additional work on these physiological questions is needed badly.

#### SUMMARY

1. Detailed life history studies were made on the cockroach, *Periplaneta americana* (Linn.)

2. The normal number of eggs per ootheca is 16; the normal rate of oviposition is one ootheca every 6-8 days; the number of oothecae produced by one female may regularly be as high as 30.

3. Embryonic development at room-temperature requires about 57 days; at optimum temperature (30° C.), 30 days.

4. There are normally ten nymphal instars of gradually increasing duration, ranging as an average from 18 days for the first instar to 50 days for the tenth.

5. An individual may reach sexual maturity in seven months under optimum conditions, but probably in nature the time is more nearly one year.

6. Body weight approximately doubles between moults (increases 1.8 times). Body length and most other linear measurements increase about 22 per cent between moults.

7. Because of their discontinuous growth, such characteristics as length of head or meta-thoracic tibia or width of the pronotum are good indices of developmental stage.

8. The logarithmic equation:  $\log W = a + bt + c \log t$ , in general fits the growth curves plotted from data collected in this study.

9. Dietary deficiency delayed or stopped moulting.

10. Roaches raised aseptically grew slowly and were under-size.

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THE LEPIDOPTERISTS' SOCIETY.—The many lepidopterists of our continent are to have an opportunity for more compact exchange of information in a mimeographed publication "The Lepidopterists' News," to be distributed by the newly organized Lepidopterists' Society of Cambridge, Massachusetts. Charles L. Remington and Harry K. Clench are co-editors of the new bulletin. A minimum fee of \$1.00 is set, but since the amount of material to be published is dependent on the sum available, larger contributions will be welcomed. Remittances should be sent to Mr. Remington at the Society's address, P. O. Box 104, Cambridge 38, Massachusetts.

The editors propose to offer only soundly scientific material. They plan a twelve-page issue, including three one-page articles each, a brief biography of some outstanding lepidopterist, and practical notes on rearing lepidoptera, collecting methods and taxonomic procedure. Book reviews and a list of published articles are also planned, and a list of members with their special interests is promised during the year. As this is written, the editors expect to mail the first issue early in May and subsequent issues each month thereafter.—A. W. L.

## A SYNOPSIS OF THE GENUS EDROTES (Coleoptera: Tenebrionidae)

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In 1824, Thomas Say described a small, black, rotund, hirsute, flightless ground tenebrionid from the eastern foothills of the Colorado Rockies as *Pimelia rotunda*, a genus which, as now defined, is excluded from the Western Hemisphere. Twenty-eight years later, Dr. J. L. Le Conte described *ventricosus* from southern California and erected the genus *Edrotes* to include both species. In 1890, Col. Thomas L. Casey began work on the genus and named *nitidus* and *globosus* from southern California and Colorado, respectively; the former related to Le Conte's *ventricosus*, the latter to Say's *rotundus*. Seventeen years later, Casey added *orbis*, *angusticollis* and *longipennis* from *ventricosus* stock, and *inflatus*, *puncticeps*, *intermixtus*, *oblongulus*, *lineatus*, *subaequalis* and *angustulus* from *rotundus* stock. In 1923, the late Dr. Frank E. Blaisdell described *mexicanus* and *asperatus*, of *ventricosus* stock, from Baja, California. The following year Casey, apparently having just received four more specimens from the West, applied to them the names *lati-collis*, *longicornis* and *variipilis*—all of *ventricosus* stock. In 1943, Dr. Blaisdell added *desertus*, of *rotundus* stock, from Baja California.

Recent examination of considerable material in the genus indicates these names to be synonyms of Say's and Le Conte's species; in the case of Casey's names, it is quite obvious that individual variations alone were being described. The status of *desertus* is discussed under *rotundus*. I am indebted to Drs. Edwin C. Van Dyke and Edward S. Ross for allowing me to examine specimens in the collection of the California Academy of Sciences, largely from the incorporated Blaisdell collection, and to Kenneth S. Hagen and William F. Barr for the use of records from their collections.

### Subfamily Tentyriinae

#### Tribe Edrotini

#### Genus *Edrotes* Le Conte

*Pimelia*, Say, 1824, Jour. Acad. Nat. Sci. Phila. 3: 251-252.

*Pimelia*, Le Conte, 1851, Ann. Lyc. Nat. Hist. N. Y. 5: 140-141; 1859, Smiths. Contrib. to Knowl., p. 44.

*Pimelia*, Lacordaire, 1859, Hist. Nat. Ins. Coleop. 5(1): 174-176.

*Edrotes* Le Conte 1851, Ann. Lyc. Nat. Hist. N. Y. 5: 140-141; 1859, Smiths. Contrib. to Knowl., p. 44.

*Edrotes*, Thomson, 1859, Arcana Naturae, pl. 12, fig. 8.

*Edrotes*, Horn, 1870, Trans. Amer. Phil. Soc., N. S., 14: 257; 1894, Proc. Calif. Acad. Sci. 2nd Series 4: 345-346.

*Edrotes*, Le Conte & Horn, 1883, Smiths. Misc. Coll. 507: 361.

*Edrotes*, Casey, 1890, Ann. N. Y. Acad. Sci. 5: 174-176, 502; 1907, Proc. Wash. Acad. Sci. 9: 450-457; 1924, Mem. Coleop. 11: 300-301.

*Edrotes*, Blaisdell, 1892, Zoe 3(2): 102; 1923, Proc. Calif. Acad. Sci. 12(12): 241-242; 1943, Proc. Calif. Acad. Sci. 24(7): 212-213.

*Edrotes*, Champion, 1892, Biol. Cent.-Amer. Coleop. 4(1): 477.

*Edrotes*, Fall, 1901, Occas. Papers Calif. Acad. Sci. 8: 161.

*Edrotes*, Van Dyke, 1919, Ann. Ent. Soc. Amer. 12(1): 9.

*Edrotes*, Sherman, 1929, Jour. N. Y. Ent. Soc. 37(3): 207, 268.

*Edrotes*, Bradley, 1930, Man. Gen. Beetles, p. 178.

*Edrotes*, Moore, 1937, Occas. Papers San Diego Soc. Nat. Hist. 2: 68.

*Edrotes*, Knowlton, 1939, Utah Agric. Exper. Sta. Mimeog. Ser. (Tech.) 200(3): 13.

Le Conte's original generic description, reproduced here because of its general unavailability, is:

"*Edrotes*.<sup>1</sup>

"*Clypeus trilobatus*, lobo medii angusta, apice subemarginato, lateralibus obtusis; mandibulae supra dente forti armatae: oculi rotundati; sterna arcte conjuncta; scutellum nullum.

"Corpus inflatum, thorace brevissimo, angulis porrectis, epipleuris maximis, coxis posticis modice distantibus. Hoc ponenda est *Pimelia rotunda* Say. J. Ac. 3, 251."

The genus may be modernly characterized as follows:

General form globose, rotund, highly convex, densely clothed (unless rubbed in old specimens) with white-to-yellow pubescence of two types: (a) (subgenus *Edrotes*) long, more-or-less erect flying hairs interspersed with shorter more-or-less erect hairs, all varying from white to golden-yellow (often arranged in longitudinal series in *E. ventricosus*); (b) (subgenus *Odotes*) short, flattened, appressed, scale-like hairs, widest in medial portion of each hair, all pointing anteriad on head, posteriad on elytra, and golden-yellow in color. Dorsum roughened variously: (a) (*E. rotundus*) roughly, coarsely and shallowly impunctate, intervening plane surfaces dull—in some specimens, the dorsal condition becomes almost tuberculate due to an increase in conspicuousness of the domed plane surfaces intervening between the roughened impunctations; (b) (*E. ventricosus*) minutely and sparsely beset with fine tubercles, each placed before a hair socket—surface otherwise smooth and glistening; (c) (*E. arens*) thickly beset with well-sized rounded tubercles, each arising anteriad of a hair socket, the intervening plane surface smooth, moderately shiny. Total length longer than wide. Head large, mandibles with a short, blunt tooth arising in medial portion and when closed, clasping the labrum; supra-antennal shelf projecting anteriad of antennal insertion. Antennae inserted adjacent to the anterior margin of the small eyes; 11-segmented, the terminal segments forming a weak club; 3rd segment the longest, subequal to 4th and 5th segments combined (*E. ventricosus* and *E. arens*) or shorter than same (*E. rotundus*); at least the terminal five antennal segments conspicuously furred with golden-yellow pile (*E. ventricosus* and *E. arens*) or with less than five terminal segments so furred (*E. rotundus*). Pronotum strongly transverse, much wider than long, the anterior angles projected as sharp, spinous processes. Elytra wider than long (*Odotes*) to longer than wide (*Edrotes*), markedly clasping body beneath; scutellum obsolete. Ventrums roughened and hirsute, with no long flying hairs, marked with

<sup>1</sup>"Genus hocce sequentibus cum duobus familiam parvam inter Pimeliarias clypei forma valde distinctam constitit, diagnosi sequente definitam: clypeus trilobatus, mentum magnum, fissura buccalis nulla; oculi superciliati; antennae 11-articulatae, tenues, articulo 3<sup>o</sup> longiore; articulo ultimo haud minore: pedes tenues tibiis filiformibus. Affines videntur *Epiphisa*, *Capnisa*, *Pterocoma*, *Prionothesa*, et *Trachyderma*."

large, circular, rimmed pits, complete or open caudad; epipleura terminating abruptly considerably caudad of lateral metacoxal angles (*Odrotres*) or varying from nearly attaining the angles to extending much anteriorly of them (*Edrotres*). Legs long, hirsute; terminal inner metatarsal spur as long as first metatarsal segment (*Odrotres*) or shorter (*Edrotres*). A supplementary generic diagnosis may be found in Casey (1907). The genotype is *Edrotres ventricosus*, as designated by Casey (1907).

The genus is distributed from the eastern face of the Rocky Mountains to the desert regions of the Pacific coast in southern California; southward into Baja California and northern Mexico, where its boundaries are indefinite, as they are to the north. I have specimens from northern Nevada and southern Idaho, and it undoubtedly occurs in eastern Oregon and possibly as far north as eastern Washington; the tolerances of *Edrotres* seem to correspond generally with those of the subgenus *Sphaeriontis* of *Eusattus*, which I have from the arid sand country around Pasco, Washington. Its limits in the vicinity of Wyoming-Montana are unknown to me. Leng catalog ranges cover only the southern portions of its distribution in the United States.

*Edrotres* is an habitué of the Creosote-Shadscale-Sagebrush belts (*Larrea-Atriplex-Artemisia*: the so-called "Sonoran Zone"), and is often quite common in arenaceous areas; my largest series have come, without exception, from sand dunes and sanded areas.

The following key will differentiate the valid forms:

1. Dorsal vestiture of short, appressed, scale-like hairs, each hair widest in the middle, tapering proximad and distad. . . . . *Odrotres arens* subg. et. sp. nov.  
Vestiture of long, slim, flying hairs interspersed with shorter hairs (subg. *Edrotres*) . . . . . 2
2. Dorsum smooth with minute but distinct, sparse tuberculations; 3rd antennal segment subequal to 4th and 5th combined. . . . . *ventricosus*  
Dorsum rough, coarsely impunctate, dull; 3rd antennal segment distinctly shorter than 4th and 5th combined. . . . . *rotundus*

#### Subgenus *Odrotres* subg. nov.

##### *Edrotres arens* sp. nov.

General morphology as described for the genus; body globose, rufous, thickly-clothed with short, flattened, appressed scale-like hairs which render the integumental details indistinct; a few slightly longer bristles of the same character adorn elytral sides, but there is nothing in the vestiture resembling the long, thin flying hairs of the subgenus *Edrotres*; vestiture golden-white, free tips pointing caudad on elytra, cephalad on head, and occupying an intermediate condition on the pronotum where, by whorling, the caudad and cephalad conditions merge without break; bristles pointing centrad on pronotal sides. Elytral pitting obsolescent, but tuberculations much larger and heavier, when capable of being seen through the dense vestiture, than in the subgenus *Edrotres*; elytra distinctly wider than long, whereas the opposite conditions prevail for other members of the genus.

ARIZONA: Yuma County (*Yuma sand dunes* 8/VI/37, el. 150 ft.—LaR). Three specimens, holotype (sex undetermined) and two paratypes in my collection.

This very distinctive species is as yet known only from the type locality, and may not be much more widely distributed, since considerable material of other species in the genus has already been collected from Arizona generally, as attested by Arizona references in the literature as well as the several species Casey described from there. The late discovery of *arens* is contributory evidence of its probable local distribution; future extensions of range will probably come from northern Mexico, a little-explored area entomologically. As the genus is now constituted, *arens* is the most distinctive of its three species. Nothing is known of the species' biology except that the three individuals known were taken on a sand dune.

### Subgenus *Edrotes* Le Conte

#### *Edrotes ventricosus* Le Conte

- E. ventricosus* Le Conte 1851, Ann. Lyc. Nat. Hist. N. Y. 5: 141.  
*E. ventricosus*, Thomson, 1859, Arcana Naturae, pl. 12, fig. 8.  
*E. ventricosus*, Horn, 1870, Trans. Amer. Phil. Soc., N. S., 14: 257; 1894, Proc. Calid. Acad. Sci. 2nd Series 4: 345-346.  
*E. ventricosus*, Ulke, 1875, Wheeler's 100th Merid. Rept., Zoölogy 5: 823.  
*E. ventricosus*, Le Conte & Horn, 1883, Smiths. Misc. Coll. 507: 361.  
*E. ventricosus*, Casey, 1890, Ann. N. Y. Acad. Sci. 5: 175—(*E. nitidus* Csy, ibid p. 175); 1907, Proc. Wash. Acad. Sci. 9: 451—(*E. orbus* Csy, ibid pp. 451-452; *E. angusticollis* Csy, ibid p. 452; *E. longipennis* Csy, ibid pp. 452-453); 1924, Mem. Coleop. 11: 300-301—(*E. laticollis* Csy, ibid p. 300; *E. longicornis* Csy, ibid pp. 300-301; *E. variipilis* Csy, ibid p. 301).  
*E. ventricosus*, Blaisdell, 1892, Zoe 3(2): 102; (1923, Proc. Calif. Acad. Sci. 12(12), *E. mexicanus* Blais. p. 241; *E. asperatus* Blais. pp. 241-242); 1943, Proc. Calif. Acad. Sci. 24(7): 212.  
*E. ventricosus*, Fall, 1901, Occas. Papers Calif. Acad. Sci. 8: 161—(*E. nitidus* Csy, ibid p. 161).  
*E. ventricosus*, Sherman, 1929, Jour. N. Y. Ent. Soc. 37(3): 207, 268.  
*Edrotes ventricosus*, Moore, 1937, Occas. Papers San Diego Soc. Nat. Hist. 2: 68—(*E. longicornis* Csy, ibid p. 68).

#### SYNONYMY:

- E. nitidus* Casey 1890, Ann. N. Y. Acad. Sci. 5: 175; 1907, Proc. Wash. Acad. Sci. 9: 452—Fall, 1901, Occas. Papers Calif. Acad. Sci. 8: 161.  
*E. orbus* Casey 1907, Proc. Wash. Acad. Sci. 9: 451-452.  
*E. angusticollis* Casey 1907, ibid p. 452.  
*E. longipennis* Casey 1907, ibid pp. 452-453.  
*E. mexicanus* Blaisdell 1923, Proc. Calif. Acad. Sci. 12(12): 241.  
*E. asperatus* Blaisdell 1923, ibid pp. 241-242.  
*E. laticollis* Casey 1924, Mem. Coleop. 11: 300.  
*E. longicornis* Casey 1924, ibid pp. 300-301.  
*E. variipilis* Casey 1924, ibid p. 301.

Le Conte's original description is:

"1. *ventricosus*, niger nitidus, pilis longissimis albidis versus latera lanuginosa, capite thoraceque impunctatis, hoc versus latera rugis paucis elevatis notato, elytris parce subtiliter punctatis, punctis versus marginem muricatis, pedibus longe pilosis. Long. .41. Habitat in desertis Colorado."

In size, the species varies from 6.4 mm. to 10.0 mm. long, and from 4.4 mm. to 6.7 mm. wide.

I can specify the following records: California Academy of Sciences material is designated CAS—specimens noted as collected by William F. Barr and Kenneth S. Hagen are parts of their respective collections. Unless otherwise specified, the remainder are in my collection.

ARIZONA: Four specimens labelled simple "Arizona" (*E. orbis*) (CAS); Maricopa County (*Tempe*, R. Ecker—*E. orbis*) (CAS); Pima County (*Tucson*, H. F. Wickham—*E. orbis*) (CAS); 26/III/12, J. R. Slevin (CAS); Yavapai County (*Prescott* 2/VI/37, el. 5400 ft.—LaR (*E. orbis*)); Yuma County (*Ehrenberg* 15/II/39, el. 300 ft.—F. H. Parker; *San Luis* 16/VI/40, el. 100 ft.—W. F. Barr; *Wellton* 5-6/V/18, J. C. Bradley (CAS); *Yuma* 21-29/X/11, el. 150 ft.—J. R. Slevin (CAS); 12-18/III/12, J. R. Slevin (CAS)).

CALIFORNIA: Imperial County (*Holtville* 3/IV/24, el. sea level (CAS); *La Puerta* 8/XI/09, X/25 (CAS); *Palo Verde* 17/VIII/46, el. 250 ft.—W. F. Barr; *Salton Sea* 22/II/17, el. 200 ft. below sea level.—J. O. Martin; 9/I/36 (CAS)); Inyo County (*Death Valley* 19/IV/26, J. D. Gander (CAS); *Furnace Creek* (Death Valley) 3/IV/39, el. 150 ft. below sea level.—W. F. Barr; *Shoshone*, G. D. Hanna (CAS)); Kern County (*Inyokern* 14/III/41, el. 2350 ft.—T. H. G. Aitken (CAS); *Randsburg* 5/IV/27, el. 2500 ft.—T. Craig (CAS)); Los Angeles County (*Antelope Valley* 19/II/26 (CAS)); Riverside County (*Coachella* 22/IX/31,—A. Williamson (CAS); *Hidden Springs* 12/III/27—T. Craig (CAS); *Indio* I/90—Wright (CAS); *Palm Springs* 26/IV/07, (CAS)); San Bernardino County (*Barstow* 20/X/35, el. 2150 ft.—E. G. Linsley (CAS); *Needles* 27/XI/21, 17/XII/21, 10/III/22, el. 500 ft.—J. A. Kusche (CAS); 1/IX/41, E. G. Linsley (CAS); *Victorville* 22/V/25 (CAS); *Yermo* 1/V/41, el. 2050 ft.—W. F. Barr); Ventura County (*Oxnard* 6/XI/12, el. 50 ft.—J. Anthony).

IDAHO: Gooding County (*Bliss* 1/VI/29).

MEXICO: *Angeles Bay* (Gulf of California 7/V/21, E. P. Van Duzee; (*E. asperatus*) (CAS); *Guaymas* 7-13/IV/21, E. P. Van Duzee (*E. mexicanus*) (CAS); *San Marcus Island* (Gulf of California) 12/V/21, E. P. Van Duzee (*E. mexicanus*) (CAS); *San Pedro Bay* (Gulf of California) 7/VII/21, E. P. Van Duzee (*E. mexicanus*) (CAS); *Tapoca Bay* (Gulf of California) 25/IV/21, E. P. Van Duzee (*E. mexicanus*) (CAS).

NEVADA: Churchill County (*Rawhide Sands* 26-28/VIII/46, el. 4200 ft.—LaR; *Sand Spring* 5/VII/41, el. 4500 ft.—LaR & Christensen; 30/VII/46,—LaR); Clark County (*Boulder City* 6/VI/31, el. 2500 ft.—S. F. Light (CAS)); Humboldt County (*Paradise Valley dunes* (near Winnemucca) 18/VI/41, el. 4800 ft.—LaR & Christensen; 31/VII/46—LaR); Lyon County (*Mason* 28/VIII/46, el. 5600 ft.—LaR); Mineral County (*Thorne dune* 7/VII/41, el. 4600 ft.—LaR & Christensen; 5/IX/46—LaR & Gibson); Nye County (*Beatty* 20/I/40, el. 3400 ft.—LaR; *Beatty dunes* (18 mi. S. of Beatty) 21/I/40, el. 3000 ft.—LaR); Pershing County (*Old Mill* (E. side of Winnemucca Sink, on W. side Nightingale Mts.) 22/VII/46, el. 4100 ft.—LaR); Washoe County (*Pyramid Lake dunes* 24/VIII/41, 1/IX/41, el. 3850 ft.—LaR & Trelease; *Truckee Meadows* (Reno) 9/XI/39, 17/III/40, el. 4500 ft.—LaR; *Wadsworth* 16/VIII/39, el. 4100 ft.—LaR; *Washoe Lake* 22/VI/40, el. 4500 ft.—LaR & Mahoney).

The total recorded distribution of *E. ventricosus* includes southern California, Nevada, southern Idaho, southwestern Utah, western Arizona, and portions of extreme northwestern Mexico. The northern limits are unknown, but it probably extends up the Great Basin into

portions of Oregon. In Arizona (Pima County), Utah (Skull Valley) and northern Mexico, it meets elements of *E. rotundus*, the latter occupying the eastern portion of the genus' range, and *E. ventricosus* the western. The line of meeting of the two species in the Colorado Plateau country of eastern Utah—western Colorado is incompletely—known. Both species occupy an area totally enclosing, so far as known, the limited range of *E. arens*.

I have examined the types of Blaisdell's *E. mexicanus* and *E. asperatus* in the California Academy of Science collection and find them conspecific with *E. ventricosus*. *E. mexicanus* was described from Guaymas and *E. asperatus* from Angeles Bay, Gulf of California. In 1894, George Horn published a list of the Coleoptera of Baja California and wrote:

"*Edrotes ventricosus* Lec. This species is very variable, and has recently been divided into forms which have received new names. I have already called attention to the fact that the same species developing at different seasons will have a very different aspect. Those developing in the hot and dry season will be shining, and if pubescent or hairy, will remain so but a short time, while the specimens of the colder or wet seasons will be opaque and retain their pubescence or hair longer. . . . One of the specimens of *Edrotes* before me has the surface dull and coated with a dirty white efflorescence. In species of other genera observed in nature by myself this seems dependent on seasonal influences also.

"*Edrotes ventricosus* occurs probably along the entire eastern side of the peninsula, but specimens have been sent from San Jose del Cabo only."

Ulke (1875) has the notation:

"*Edrotes ventricosus*, Lec." from "California," taken in "1871," by "F. Bischoff."

E. A. Schwarz, in a letter dated Dec. 9, 1896 (Sherman 1929), commented regarding material which Hubbard collected in Arizona:

"The 'little hairy globular Tenebrionid' must be an *Edrates*" (*Edrotes*) "but the small species *E. rotundatus*" (*E. rotundus*) "is known only from Colorado and Wyoming whereas the species known from Arizona, *E. ventricosus* cannot be called 'small.' It is as big as a potato beetle."

In another reply to Hubbard, dated Mar. 22, 1897, regarding material Hubbard recently sent him from the vicinity of Palm Springs, California:

"The series of *Edrotes* is very interesting and quite puzzling; the two smallest specimens came close to *E. rotundatus*" (*E. rotundus*) "Say from Colorado and Wyoming, while the larger specimens are intermediate between *E. ventricosus* Lec. and *E. ustidus* Casey" (*E. nitidus*). "I think the whole is only one species extremely variable in size, punctuation and nature of pubescence."

In 1901, Fall listed *Edrotes ventricosus* from southern California:

"*E. ventricosus* is not uncommon on the Colorado Desert; I have taken it under stones at Palm Springs, on the western border of the desert, in April. With typical specimens of *ventricosus* occurred others



of duller surface lustre, with coarser punctuation and pubescence less evidently condensed in lines along the elytra; these Dr. Horn considered as mere varieties of *ventricosus*, and if his opinion is well founded probably *nitidus*, described from the Mojave Desert, should be similarly disposed of."

Moore's (1937) notation on the species is merely "Taken from dung in the desert from spring to fall."

What little I know of *Edrotes* biology applies to *ventricosus*. My specimens have all been taken on sand dunes or sanded areas, and appear quite early in the spring and are among the last to disappear when winter weather sets in. My earliest Reno record is March 17, at which time the weather is too inclement generally for most insects—my latest record is November 9, long after most insects have disappeared. This seems to indicate overwintering of the adults who respond to occasional warm days to search for food. Farther south, in the vicinity of Beatty, Nevada, they are active the year around as shown by large series taken in January. The immediate environs in which I took them here in greatest abundance were sanded beaches along the Amargosa River, which in winter has some water in it until it reaches the flats south of Beatty. Common associates were *Eleodes armata* Le Conte 1851, *Eleodes immunis* Le Conte 1858 and *Eusattus dilatatus* Le Conte 1851.

About Reno, the immediate environment of *E. ventricosus* is somewhat less rigorous than its usual desert habitat, my most prolific collecting spot being a sagebrush—rabbitbrush association (*Artemisia-Chrysothamnus*) bordering a vigorous stand of saltgrass (*Distichlis spicata*); the adjacent bottomland, once Truckee River swamps and marshes, is now under cultivation. The ground is somewhat sandy, and the spot is well populated with *Cicindela tranquebarica borealis*, Harris 1911, *C. t. kirbyi* Le Conte 1866, *C. plutonica leachi* Cazier 1936, *C. oregona* Le Conte 1857, *Eleodes nigrina* Le Conte 1858, *E. pilosa* Horn 1870, *E. hirsuta* Le Conte 1861, *Coniontis lariversi* Blaisdell 1941, *Helops opacus* Le Conte 1859, *Calosoma zimmermanni* Le Conte 1849 and *Blapstinus crassicornis* Casey 1890. At nearby Pyramid Lake, more typical desert arenaceous conditions prevailed, and predominant associated species included *Cryptoglossa verrucosa* Le Conte 1851, *Eleodes armata striatipennis* Blaisdell 1942, *Trogloclerus costatus nevadus* La Rivers 1942, *Ceuthophilus fossor* Hubbell 1936, *Ammobaenetes lariversi* Strohecker 1944, and *Niptus ventriculus* Le Conte 1859.

*Edrotes ventricosus* seem strict herbivores, and I have found them feeding on saltgrass (*Distichlis spicata*) brome grass (*Bromus tectorum*), Russian thistle *Salsola kali tenuifolia* and wild onion (*Allium* sp.). Like most tenebrionids, their well-developed scent seems to make them undesirable as animal food, and I have never noticed them in the abundant pellets of the burrowing owl (*Speotyto cunicularia hypugaea*) or the droppings of the coyote (*Canis latrans lestes*), animals common to the area and pronounced insectivores during portions of the year.

Size decreases markedly in the northern reaches of the species' distribution, specimens from Reno averaging only slightly more than half the size of extreme southern Nevada and Arizona material. Series

from sand dunes usually show varying loss of pilosity, probably due to the abrasive effect of the sand.

### *Edrotes rotundus* (Say)

*Pimelia rotunda* Say 1824, Jour. Acad. Nat. Sci. Pihla. 3: 251-252.

*P. rotunda*, Le Conte, 1851, Ann. Lyc. Nat. Hist. N. Y. 5: 141.

*Edrotes rotundus*, Le Conte, 1859, Smiths. Contrib. to Knowl., p. 44.

*E. rotundus*, Horn, 1870, Trans. Amer. Phil. Soc., N. S., 14: 257.

*E. rotundus*, Le Conte & Horn, 1883, Smiths. Misc. Coll. 507: 361.

*E. rotundus*, Casey, 1890, Ann. N. Y. Acad. Sci. 5: 175 (misspelled *rotundatus* in the key), 502—(*E. globosus* Csy, *ibid* pp. 175, 502); 1907, Proc. Wash. Acad. Sci. 9: 453—(*E. globosus* Csy, *ibid* p. 454; *E. inflatus* Csy, *ibid* p. 454; *E. puncticeps* Csy, *ibid* p. 454; *E. intermixtus* Csy, *ibid* p. 455; *E. oblongulus* Csy, *ibid* p. 455; *E. lineatus* Csy, *ibid* pp. 455-456; *E. subaequalis* Csy, *ibid* p. 456; *E. angustulus* Csy, *ibid* p. 456).

*E. rotundus*, Sherman, 1929, Jour. N. Y. Ent. Soc. 37(3): 207, 268.

*E. rotundus*, Knowlton, 1939, Utah Agric. Exper. Sta. Mimeo. Ser. (Tech.) 200 (3): 13.

*E. rotundus*, Blaisdell, 1943, Proc. Calif. Acad. Sci. 24(7): 212-213—(*E. desertus* Blais, *ibid* pp. 212-213).

#### SYNONYMY:

*E. globosus* Casey 1890, Ann. N. Y. Acad. Sci. 5: 175-176, 502; 1907, Proc. Wash. Acad. Sci. 9: 454.

*E. inflatus* Casey 1907, Proc. Wash. Acad. Sci. 9: 454.

*E. puncticeps* Casey 1907, *ibid* p. 454.

*E. intermixtus* Casey 1907, *ibid* p. 455.

*E. oblongulus* Casey 1907, *ibid* p. 455.

*E. lineatus* Casey 1907, *ibid* pp. 455-456.

*E. subaequalis* Casey 1907, *ibid* p. 456.

*E. angustulus* Casey 1907, *ibid* p. 456.

*E. desertus* Blaisdell 1943, Proc. Calif. Acad. Sci. 24(7): 212-213.

Say's difficult-to-obtain original description of *E. rotundus* and some of his pertinent observations are repeated here:

#### "PIMELIA Lat.

"*P. rotunda*.—Black, with a few white hairs; anterior thoracic angles prominent, acute.

"Inhabits Arkansas.

"Body rounded, black, immaculate, with numerous white hairs arising from excavated punctures: head, anterior termination truncate, and much narrowed by the concavity of the lateral edge; over the insertion of the antennae, a prominent acute angle; antennae blackish-piceous; second, fourth, fifth, and sixth joints, equal; third slightly longer, obconic-cylindric; remaining joints more ovate, two or three terminal ones rather larger, the last acute at tip; palpi dark piceous, terminal joint truncate at tip; thorax very short and wide; anterior angles prominent, acute; punctures of the lateral margin much dilated, excavated, confluent; those of the disk smaller and distinct; lateral edge rectilinear: elytra with profound, excavated punctures at base, and smaller and less indented ones towards the tip.

"Length less than one-fourth of an inch.

"This species we observed only within the distance of a hundred miles from the Rocky Mountains. In the form of the body it very closely resembles Olivier's figure of his *P. inafita*, the *P. flavicollis* of Fabricius. This new species I believe be the first of this genus that has yet been found on this continent."

In size, the species varies from 5.4 mm. to 7.5 mm. long, and 3.6 mm. to 4.8 mm. wide.

I have seen specimens of *E. rotundus* from the following localities:

ARIZONA: Cochise County ("Benson" (CAS) (*E. lineatus*)); Pima County (Fort Grant 26/VIII/33.—Bryant (CAS) (*E. intermixtus*));

Santa Cruz County (*Sonoita* 3/VIII/24.—E. P. Van Duzee (CAS) (*E. intermixtus*)).

COLORADO: Denver County (*Denver*.—Bock (CAS)); Otero County (*Manzanola* 25/III/33.—J. L. Hoerner (CAS)); Weld County (*Greeley* 16/VIII/39.—C. L. Jensen (LaR col.)).

NEW MEXICO: Colfax County (*Koehler* (CAS)); Santa Fe County (*Santa Fe* (CAS)); Socorro County (*Magdalena* 8/VI/40.—T. S. Sloan (LaR col.); *San Marcial* 22/VI/21.—C. D. Duncan (CAS)).

TEXAS: El Paso County (*El Paso* 2/VI/40. —T. S. Sloan (LaR col.); Jeff Davis County (*Davis Mountains* 9/VII/21.—C. D. Duncan (CAS)); Presidio County (*Valentine* 1/V/27.—J. O. Martin (CAS)).

The range of *E. rotundus* includes Colorado, western Texas, New Mexico, portions of Utah (Tooele County (*Delle* (Skull Valley) VIII/33, el. 4300 ft.—G. F. Knowlton)) (Knowlton 1939), at least eastern Arizona, northern Mexico and Baja California. It probably extends north at least to Wyoming, but I know nothing of its possible occurrence in the Colorado Plateau country between the southern Rockies and Great Basin, where it probably meets *E. ventricosus*. The vicinity of Pima County, Arizona, is one of the known points of contact between the two.

Since Casey's types are unavailable except to on-the-spot workers, I have found it necessary to utilize Blaisdell-determined material in the California Academy collection (which I hold in as much esteem as Casey-determined specimens) and material I have managed to accumulate from as many localities as Casey specifically mentions, and which I regard as topotypic. These include Colorado (Greeley), New Mexico (Magdalena), Arizona (Benson) and western Texas. Since nothing that does not perfectly fit Casey's description of *E. angustulus* has been seen from Texas, there is no need of a more definite locality to be specified in considering such material topotypic.

It is quite obvious, after seeing the extensive series examined during the course of this study, that the component units of the genus *Edrotes* are widely variable, and it is not to be wondered that Casey compounded so many species, possessing, as he did, only short series from widely-scattered localities. While there are important details of distribution still to be pressed for solution, there is enough material on hand to definitely iron out the synonymy, which, for so small a genus, had become quite cumbersome. Dr. Blaisdell's *E. desertus* is superficially a separable population in that the tendency toward lowered convexity of the lateral elytral outlines, as viewed dorsad, seems constant in the San Ignacio area of Baja California from which the type series came; such tendency results in individuals with distinctly more parallel-sidedness than is usual for the genus; however, it differs in no other respects from typical *E. rotundus*, and the fact that such loss of convexity is not uncommon in a typical series of the latter renders the character invalid. *Desertus* represents merely a biotypic segregation of a minor variation.

As mentioned, members of *Edrotes* are representative of a natural group in a state of flux. Should one or more areas in its present distribution become isolated for geologic periods, *Edrotes* stock there, with its profuse variability potential, could no doubt produce distinctive species—such groups as this, and the similarly variable *Trogloderus*,

undoubtedly represent major sources from which come extensive specific and generic differentiation after geologic times of great stress and physiographic change.

As regards the relationships of *Edrotes*, *E. ventricosus* and *E. rotundus* are obviously much more closely-related to each other than to *E. arens*, which latter is unique in its possession of flattened, sword-shaped, almost scale-like hairs differing profoundly from the long-haired vestiture of the subgenus *Edrotes*. However, as brought out in the *diagnosus compositus*, *arens* and *ventricosus* share certain characters of antennal structure and dorsal tuberculation not found in *rotundus*, characters which probably are more indicative of what the prototypic *Edrotes* looked like than of definite affinities among members of the genus as it is now constituted. Any deep search for lineal connexions would demand close scrutiny of southern South American genera as well as analyses of related Central American forms. In the United States, *Edrotes* stands isolated and alone.

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THE ROCKEFELLER FOUNDATION, A REVIEW FOR 1946, by RAYMOND B. FOSDICK. New York.

Dr. Fosdick reveals in this report that the appropriation of \$19,481,576 represents an increase of \$8,000,000 over 1945. It includes \$7,500,000 granted to the General Education Board.

Aside from the indirect value of these expenditures to all of us as citizens of a world struggling for harmony, the continued support of work against mosquitoes as vectors of malaria and yellow fever is directly interesting to entomologists. The activities of the German army in Italy resulted in a serious setback to the control of malaria, as had happened three times before as a result of war. American efforts this time, thanks to modern methods and the availability of DDT, have been important in quickly reducing the danger from malaria to a negligible point.

The Foundation has also supported vigorous research on the problem of yellow fever and its vectors in Africa, although here the study is far more a problem of investigation and the abatement of danger to man cannot yet be expected.

One can easily imagine that a survey of the appropriations for support of biological projects will bring up some questions in the mind of any reader particularly if he struggles with no financial backing whatever to make his own small contribution to scientific knowledge. But the evaluation of thousands of applications must be a difficult task, and the devotion of \$2,510,140 during the year to biological investigation deserves the gratitude of all biologists.

As is always true, the work of the Foundation as revealed by Dr. Fosdick's annual review is an enlightening example of the philanthropic enterprises of the United States of America. To the reviewer it is also among the strongest proofs of the value of free, individual enterprise as it has developed in our land.

—A. W. L.

# CLASSIFICATION OF THE CRYPHOCRICINAE

(Hemiptera: Naucoridae)

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The subfamily Cryphocricinae as now restricted (Usinger, 1941) consists of the single genus *Cryphocricos* Signoret (1850). *Cryphocricos* is one of the least known and most unique genera of water bugs. Less than a dozen specimens were recorded in the literature from 1850 to 1941 and nothing at all was published concerning the biological or morphological peculiarities of the group until that time.

## HISTORY

The original description and figures of *Cryphocricos barozzii* (Signoret, 1850) were based upon a single brachypterous male from Brazil. Mayr (1868) recorded the first female and emended the generic name to *Cryphocricus*.

Stål (1876) in his masterful classification of the Naucoridae did not assign "*Cryptocricus*" (another emendation for *Cryphocricos*) or *Ambrysus* to a "division" because, as stated in a footnote, "*Exemplus hujus generis (Cryptocricus), quod vidi unicum, maxime mutilum.*" The damaged specimen to which Stål referred was from Brazil and was considered to be Signoret's species.

The fourth reference to the genus is contained in Montandon's revision of the "*Cryptocricinae*" (Montandon, 1897a). I have shown elsewhere (Usinger, 1938) that Montandon was dealing with a polyphyletic group including genera from New Guinea and Madagascar which belong in the Cheirochclinae. I have also shown (Usinger, 1941) that Montandon was in error in placing "*Cryptocricus*" and *Ambrysus* in the same subfamily. In the above mentioned paper Montandon did give a useful redescription of Signoret's type which he borrowed from the K. K. Hofmuseum in Vienna. Unfortunately he introduced a confusing error at this time, recording Signoret's type specimen from Chile. In the same year (1897b) Montandon described an entirely different insect, *macrocephalus*, in "*Cryphocricus*." This has since been made the type of a new genus, *Cataractocoris*, in the subfamily Ambrysinac (Usinger, 1941).

In 1911, Montandon described the first macropterous *Cryphocricos*, e. g. *breddini*, from Ecuador. This was a radical extension of the generic concept. It is interesting to note that the affinities of this specimen were recognized by Breddin whose label, "*Cryphocricus barozzii* Sign. macroptera," was quoted by Montandon.

Nothing further was published on *Cryphocricos* until De Carlo (1931) recorded a brachypterous specimen (as *barozzii*) from Argentina. Later De Carlo (1940) made the Argentine specimen the type of a new species, *daguerrei*, and described two additional species, *peruvianus*, based upon a unique male from Peru, and *rufus*, based upon a male and female from Brazil. All of these specimens were brachypterous. The descriptions were supplemented by very useful line drawings in a later paper (De Carlo, 1941).

## SOURCES OF PRESENT MATERIAL

Since 1930, large collections of Cryphocricinae have been accumulated by Dr. H. B. Hungerford at the University of Kansas and by me at the California Academy of Sciences and the University of California. Hundreds of brachypterous specimens and twenty-three macropterous specimens are now available from twelve different localities in Brazil, Ecuador, Colombia, Peru, Panama, Costa Rica, Mexico and Texas. I am particularly indebted to Dr. Hungerford for the loan of his entire collection of these insects. My own collecting of *Cryphocricos* was done in 1933 near the village of Temascaltepec, State of Mexico. Many nymphs and brachypterous and macropterous adults were taken, thus providing ample material for systematic and morphological studies.

## MORPHOLOGY

*Cryphocricos* exhibits certain morphological peculiarities which have a bearing on its systematic position. The following discussion of the more obvious external structures which distinguish these bugs from the Ambrysinae is quoted from Usinger (1941):

"These insects are dimorphic, much as in the old-world subfamily Aphelocheirinae, the brachypterous form being commonest and differing so completely from macropterous forms, particularly as regards thoracic development, that the two would be placed in separate genera by a person unfamiliar with the group. Also as in the case of the Aphelocheirinae (which are among the very few adult aquatic insects able to survive indefinitely without direct contact with the surface) and doubtless as a consequence of their brachypterous condition some special means of respiration is necessary. This follows because the cavity between the folded hemelytra and wings and the dorsal surface of the abdomen is normally used by Naucorids as an air reservoir, the air being admitted by parting the hemelytra from the tip of the abdomen and breaking through the surface film at this point. The air may then be changed as needed via a protected notch on either side of the base of the abdomen to the abdominal venter where it is seen characteristically as a silvery film covering the under surface of the body. This film is maintained by a dense coating of hydrofuge hairs and Ege (1915) has shown that, due to the difference in rates of diffusion of oxygen and nitrogen and to the fact that oxygen is constantly being used up in the insect's air film, this film may actually serve as a breathing mechanism extracting dissolved oxygen from surrounding water. Now the brachypterous forms of both the Cryphocricinae and the Aphelocheirinae lack the hemelytral covering so necessary in obtaining the original air supply from the surface and also lack the dense coat of hydrofuge hairs so necessary in maintaining the ventral air film. Hence the special spiracular structures of the Aphelocheirinae described in detail by Szabo-Patay (1924) have been developed as a means of extracting dissolved oxygen from the water. The Cryphocricinae possess still different spiracular structures which need to be studied both biologically and histologically with fresh material."

The biological and histological studies mentioned above still remain to be done. However, some light may be shed on the subject as a result of studies made by clearing dried specimens with KOH. Also,

nymphs collected in alcohol were available for dissection. From this material, the following facts were ascertained:

1. The spiracles which open on the apodeme between the metathorax and the first abdominal segment are dorsal in *Cryphocricos* adults. This corresponds to the situation in most other water bugs and is in contrast to the condition found in *Aphelocheirus* (Larsen, 1938).

2. The "disk-like plates" mentioned by me (1941) as "spiracular structures" are not directly connected with main branches of the tracheal system. The tracheae branch off of main tracheal trunks, much as in *Nepa cinerea* Linn. (Maulik, 1916), but they are attached to the body wall and open through spiracles at some distance from the "disk-like plates." These plates occur laterally on ventral segments two (first visible) to seven, the plates of the second segment being the largest. Similar organs occur on the second segment only of *Aphelocheirus* (Larsen, 1938) and on the third, fourth and fifth segments of *Nepa cinerea* Linn. (Baunacke, 1912) and *Ranatra linearis* Linn. (Larsen, 1938). Baunacke, in particular, has made detailed histological sections of these structures and gives beautiful illustrations of their structure.

These structures have been variously termed "sieve plates," "static sense organs" (Baunacke, 1912), and "abdominal sense organs" (Hamilton, 1931). According to Hamilton, "The organs apparently function as hydrostats in keeping the animal oriented in the right direction by the pressure of water. . . ." This summation of the probable function of the organs represents the now generally accepted view. Certainly the sensory nature of the organs is clearly established. The hydrostatic theory, however, should be re-examined in the light of present knowledge of the occurrence of the organs in the Nepidae, Aphelocheirinae, and Cryphocricinae. These groups of water bugs differ from others in only one feature, e. g., they do not carry atmospheric air with them as a silvery bubble on the abdominal venter. The structures occur only in the adults and Maulik (1916) points out that adult Nepids need to spend prolonged periods of time without direct contact with the surface in connection with reproductive activities.

It is well known that *Aphelocheirus*, by virtue of its "spiracular rosettes," can remain beneath the surface for extended periods of time, extracting dissolved oxygen from the well-aerated waters in which it lives. *Cryphocricos* has no such spiracular rosettes but it is commonly brachypterous like *Aphelocheirus* and lacks ventral pubescence as in *Aphelocheirus*. I did not experiment with *Cryphocricos* specimens to see how long they could remain under water, but I did collect all of my specimens in rushing cataracts and in the swiftest flowing portions of streams where oxygen would be most abundant. Therefore it might be well to investigate the possible relationship of the abdominal sense organs to the ability of the bugs to detect the presence of dissolved oxygen and thus orient themselves in the water so as to be exposed to maximum concentrations of  $O_2$ .

3. The male genital capsule of *Cryphocricos* is similar to that of *Ambrysus* in general shape and in development of parameres but the aedeagus has a very long coiled flagellum. In a bug whose entire body was 8 mm. long, the uncoiled flagellum measured 17 mm.



4. *Cryphocricos* nymphs possess a pair of well developed abdominal scent glands with openings widely separated on the hind margin of the third abdominal tergite. These openings are also present in the adults but glands were not detected in adults. Similar openings were observed in other Naucoridae.

#### TAXONOMY

*Cryphocricos* specimens exhibit relatively few characters which are useful to the taxonomist. The coloration is rather uniform, the male genitalia are quite similar throughout and such differences as are seen in the female genital plates are quite variable. As in some other Naucorid groups, each species has a distinctive facies but the differences are illusive or difficult to describe, e. g. degree of convexity or curvature of pronotal or other margins. In *Cryphocricos* the situation is further complicated by dimorphism.

De Carlo (1940) was the first to develop a "species concept" in *Cryphocricos*. He not only employed such useful characters as size, curvature of pronotal and hemelytral margins, and curvature of connexival margins, but he also laid down a diagrammatic pattern by which these characters could be shown. I have reproduced his figures below and have given comparable diagrams of the males of my new species. I have found that relative length of scutellum vs. hemelytral commissure, relative width of embolium vs. total width of hemelytron, and size and acuteness of the posterior connexival angles are useful specific characters.

Unfortunately, most of the characters mentioned above are useful for brachypterous specimens only. The form of the postero-lateral angles of the fifth abdominal segment (males) or sixth segment (females) applies equally well to both forms but no other useful characters except size have been found. Furthermore, no method is available for associating macropterous specimens with brachypterous specimens of the same species except by inference when they are collected at the same time and place. Under the circumstances, I have tentatively lumped macropterous specimens from Ecuador and Peru together and have placed a series of macropterous specimens from Colombia as *baroszii* because no brachypterous specimens were available for confirmation.

Measurements in this paper are given as proportions, using an eyepiece micrometer with 20 units equal to 1 mm. The oculars used were 9X and the objective was 1X. Total length, measured from tip of abdomen to base of labrum, and total width measured across widest part of abdomen, are given in mm. Scutellar length is measured from the base, not including depression, to apex. This length is often compared with length of the hemelytral commissure which is measured from the apex of scutellum to level of apices of hemelytra pads. The width of embolium as compared with total width of hemelytron is measured in one plane with the insect horizontal and the pin vertical. The projections on the lateral margins of the pronotum are counted most readily as seen at an oblique angle latero-ventrally. The teeth are counted regardless of size, although they are not considered after they become so small as to be confused with granules near the anterior and humeral angles.

Subfamily *Cryphocricinae* (Montandon)

*Cryptocricinae* Montandon, 1897, Verh. zool.-bot. Gesell. Wien, 47: 2 (part.).

*Cryphocricinae* Champion, 1901, Biol. Centr.-Amer., Rhynch. 2: 354.

*Cryphocricinae* Usinger, 1941, Ann. Ent. Soc. Am., 34: 8.

Head deeply set in triemarginate anterior margin of pronotum. Rostrum short and tapering, inserted anteriorly, the labrum well developed, hinging at anterior margin of head. Antennae short, completely concealed beneath head. Hemelytra complete and fully formed with clavus, embolium and membrane, or reduced to truncate pads without clavus or membrane. Prosternum completely exposed, not covered by propleural plates. Abdominal venter naked, with plate-like abdominal sense organs adjacent to the spiracles on abdominal segments II to VII.

Type Genus: *Cryphocricos* Signoret.

This monotypic subfamily is confined to the Sonoran and Neotropical regions. Its systematic position is closest to the *Ambrysinae*. However, the exposed prosternum, abdominal sense organs, naked venter, and dimorphism set the *Cryphocricinae* apart from all other *Naucorids*.

Genus *Cryphocricos* Signoret<sup>1</sup>

*Cryphocricos* Signoret, 1850, Rev. Mag. Zool. (2) 2: 290, pl. 4, fig. 10.

*Cryphocricos* Usinger, 1941, Ann. Ent. Soc. Amer. 34: 5, fig. 1.

*Cryphocricus* Mayr, 1868, Reise Freg. Novara, Zool. II, Abt. 1, B. Hem. p. 182.

*Cryphocricus* Champion, 1901, Biol. Centr.-Amer. Rhynch. 2: 354.

*Cryptocricus* Stål, 1876, Enum. Hemipt. 5: 141.

*Cryptocricus* Montandon, 1897, Verh. zool.-bot. Gesell. Wien, 47: 6.

Oblong-oval to quite parallel-sided. Very flat beneath and moderately elevated above. Surface dull, granular above.

Head small, less than half as wide as pronotum behind. Anterior margin extending well beyond eyes, its sides subparallel, truncate at apex. Subgenal plates prominent, extending beyond apex of head. Labrum conspicuous, rounded at its apex. Gula tectiform. Eyes prominent, subglobular. Antennae with second segment longer than third. Proportion of segments 5 : 5 : 2 : 10.

Pronotum widened posteriorly, sides rounded to subrectilinear, subdepressed, crenulate or dentate. Disk finely impressed longitudinally, with a distinct transverse impression posteriorly. Postero-lateral angles rounded, projecting posteriorly over bases of hemelytra.

Hemelytra usually abbreviated, covering only the first and part of the second visible abdominal segments, with embolium distinct but without clavus or membrane. Hemelytral commissure in brachypterous specimens brief, not longer than scutellum. Macropterous specimens with clavus, embolium and membrane distinct, the embolium strongly depressed along inner margin. Wings absent in brachypterous specimens, well developed in macropterous specimens.

Abdomen with connexival angles not or scarcely produced, little more than right angles, the fourth segment in the male and the fifth and sixth

<sup>1</sup>Signoret gave the Greek roots and French translation of this name. There is one typographical error in the Greek and the perfectly acceptable "Crypho" was used in the translation instead of "Crypto." Unfortunately, the Greek ending "os" was not changed to "us" when the word was Latinized but the Latinization of such endings is only a recommendation. Under the circumstances, the original orthography is maintained.

segments in the female briefly to distinctly produced. Male with the fourth visible segment above strongly produced over genital segment.

Male genital segments freely rotatory on a central axis, asymmetrical, the seventh tergite with a dorso-laterally directed tapering spine on the right side extending from inner margin over half the distance to outer margin. Seventh ventrite well developed, broadly roundly emarginate at apical margin, leaving about half of the genital capsule exposed. Genital capsule broad, subrectangular, the apical plate dorsally nearly square, narrowly rounded at posterior angles and feebly bisinuate along anterior margin. Parameres very short, suboval. Aedeagus with phallosome narrowed at base, expanded apically, with a coiled flagellum 17 mm. long.

Female genital segments symmetrical, the seventh sternite shallowly concave or biemarginate at apex. Gonapophyses all long, slender, finger-like, the ventral pair thickest, straight and parallel, the middle pair tapering and converging apically, the lateral pair very slender, sinuous.

Front tarsi one-segmented and bearing a single claw. Intermediate and hind tarsi three-segmented, bearing two claws.

Genotype: *Cryphocricos barozzii* Signoret.

#### KEY TO THE SPECIES OF CRYPHOCRICOS

##### A. Brachypterous Specimens

1. Postero-lateral angles of fourth (♂) or fifth and sixth (♀) abdominal segments not at all or scarcely produced, obtuse or rounded. North and Central American species. . . . . 2
- Postero-lateral angles of fourth (♂) or fifth and sixth (♀) abdominal segments briefly but acutely produced. South American species. . . . . 5
2. Size small, less than 7½ mm. long. Panama, Costa Rica. . . . . 3
- Size larger, over 7½ mm. Mexico and Texas. . . . . 4
3. Body much less than half as wide across abdomen as long, 46 : 112. Commissure of hemelytra shorter than scutellum, 16 : 22. Length less than 7 mm. Panama. . . . . *obscuratus*
- Body nearly half as wide across abdomen as long, 56 : 115. Commissure of hemelytra subequal to scutellum. Length over 7 mm. Costa Rica. . . . . *latus*
4. Hemelytra short, the distance from apex of scutellum to apices of hemelytra about half the length of scutellum. Embolium narrow, about one-tenth the total width of hemelytron. Size 8 to 8½ mm. . . . . *mexicanus*
- Hemelytra longer, nearly as long from apex of scutellum as total length of scutellum. Embolium wider, one-seventh the total width of hemelytron. Size 8½ to 10 mm. . . . . *hungerfordi*
5. Lateral margins of second and third abdominal segments each slightly arcuate. Argentina. . . . . *daguerrei*
- Lateral margins of second and third abdominal segments following evenly the curve of the abdomen. . . . . 6
6. Apical margins of hemelytra straight, rather abruptly rounded laterally. . . . 7
- Apical margins of hemelytra arcuate, broadly rounded laterally. . . . . 8
7. Size large, over 10 mm. Brazil. . . . . *barozzii*
- Size smaller, less than 10 mm. Peru. . . . . *peruvianus*
8. Body over half as wide as long, 33 : 60. Brazil. . . . . *rufus*
- Body not or scarcely half as wide as long. Peru, Ecuador. . . . . *breddini*

##### B. Macropterous Specimens

1. Postero-lateral angles of fourth (♂) or fifth and sixth (♀) abdominal segments not at all or scarcely produced, obtuse or rounded. North American species. . . . . 2
- Postero-lateral angles of fourth (♂) or fifth and sixth (♀) abdominal segments briefly but acutely produced. South American species. . . . . 3

2. Postero-lateral angles of fourth ( $\sigma^7$ ) or fifth and sixth ( $\rho$ ) abdominal segments scarcely produced, obtuse at apices. Length over 10 mm. *hungerfordi*
- Postero-lateral angles of fourth ( $\sigma^7$ ) or fifth and sixth ( $\rho$ ) abdominal segments little more than right angles. Length less than 10 mm. .... *mexicanus*
3. Length over 11 mm. Colombia. .... *barozzii*
- Length less than 11 mm. Ecuador, Peru. .... *breddini*

***Cryphocricos mexicanus*, new species**

Body over twice as long as broad, 165 : 80; surface without white incrustation, the dorsal surface of head and abdomen much more finely granulate than thorax and hemelytra.

Head a little broader, eyes included, than long on median line, 18 :: 15, extending twice as far behind the eyes as in front of them. Interocular space rather convex, at narrowest point less than twice as

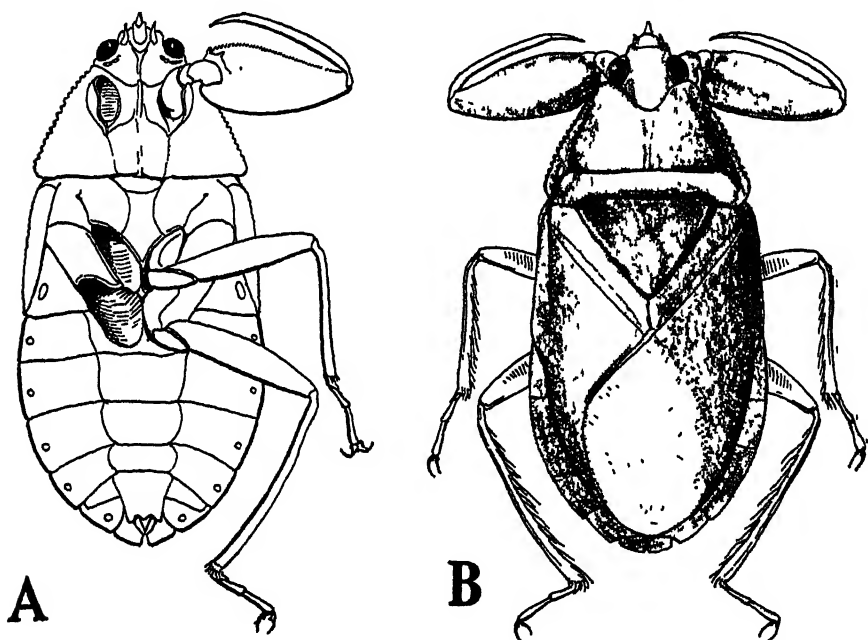


FIG. 1. *Cryphocricos mexicanus*, n. sp. A. Ventral view, female, diagrammatic. B. Dorsal view, macropterous female.

broad as transverse width of an eye, at widest point just behind eyes well over twice as broad as an eye, extending scarcely more than one-half the transverse diameter of an eye beyond the eyes. Sides of anteocular portion slightly converging anteriorly, the anterior margin truncate.

*Brachypterous form.* Pronotum equal to length of head on median line, over twice as broad posteriorly as long, 37 :: 15. Antero-lateral angles right angles at point of contact with eyes, then briefly extending transversely and thence strongly rounded; sides strongly divergent posteriorly, subrectilinear on middle three-fifths, rounded at posterior fifth, and convergent behind this; postero-lateral angles strongly

roundly produced behind posterior margin, the posterior margin straight and depressed before base of scutellum. Side margins coarsely crenulate posteriorly, becoming progressively more finely serrate anteriorly with about 27 rounded projections on either side.

Scutellum very strongly, transversely impressed at base, not quite twice as broad as long, much longer than hemelytral commissure, 27 :: 16.

Hemelytra very short, reaching only to base of second visible abdominal segment, about as long as broad at their truncate apices, the sides rather evenly arcuate, subparallel on posterior half. Embolium one-tenth the total width of hemelytron.

Color ferrugineous, the middle and hind legs paler, fulvous, the pronotum, scutellum, and dorsal part of the abdomen sometimes darker, piceo-ferrugineous. The eyes black.

Size: male, length 7.93 mm., width 3.92 mm.; female, length 8.58 mm., width 4 mm.

*Macropterous form.* Pronotum longer than head on median line  $16\frac{1}{2} :: 14$ , over twice as broad as long  $42 :: 16\frac{1}{2}$ . Lateral margin, briefly angulate at point of contact with eyes, then briefly transversely directed after which they are strongly rounded and thence strongly divergent and rectilinear to posterior angles. These latter rounded laterally, perfectly straight along posterior margin of the moderately extended prolongation over base of clavus. Posterior margin feebly arcuate over base of scutellum. Sides coarsely crenulate throughout their length; disk with a very obscure, ill-defined depression at the middle on either side. A faint depression anteriorly at middle. Scutellum much broader than long,  $31 :: 19$ , with a sinuate transverse impression at middle of base and an oblique, slightly elevated smooth vitta at each basal angle. Hemelytra complete, reaching almost to tip of abdomen; claval commissure little more than half as long as scutellum, emboliar margins briefly rounded basally, then rectilinear and parallel to just before apices where they are evenly rounded to point of joining with corial margins, forming a concave angle. Corial margin narrowly extending almost to apex of hemelytron, enclosing the basal two-thirds of the membrane which is clearly differentiated from apical margin of corium. Connexivum narrowly extending beyond level of emboliar margin, exposed, the postero-lateral angles blunt right angles. Front femora more than twice as long as broad,  $30 :: 14$ .

Color grayish-fuscon to black with a ferrugineous admixture. Front legs and middle of head ferrugineous, the eyes, scutellum, and membrane black, the lateral margin of the corium apically dark brown to black. Under side mostly light brown to ferrugineous. Middle and hind legs with femora fuscous, the tibiae and tarsi paler. Spiracular plates testaceous.

Size: male, length 8.08 mm., width (abdomen) 3.92 mm.; female, length 10 mm., width (abdomen) 4.83 mm.

The female differs from the male, aside from genitalic characters, in that the lateral margins of the pronotum are imperceptibly sinuate at about the posterior third, and the emboliar margins are distinctly sinuate at middle, being slightly divergent posteriorly. The median genital plate is distinctly biemarginate apically.

*Holotype*, brachypterous male, No. 5684, Calif. Acad. Sci., Ent. and *allotype*, brachypterous female, No. 5685, Calif. Acad. Sci., Ent., and a long series of brachypterous *paratypes*, Temascaltepec, District of Temascaltepec, Mexico, July 11, 1933 (H. E. Hinton and R. L. Usinger). These specimens were taken in a small rushing stream amidst small pebbles and rocks. They were collected by holding the net downstream and turning over the rocks, brushing the rock surfaces to dislodge specimens which clung to them. One hundred and forty specimens were taken along approximately two hundred yards of the stream. Nymphs occurred with the adults. All adults were brachypterous.

One male and three female macropterous specimens were taken 30 miles distant and 2000 feet lower at Tejupilco, District of Temascaltepec, Mexico, June 18 and 21, 1933 (H. E. Hinton and R. L. Usinger). These were taken in riffles of a swift flowing stream also. They agree in general with the brachypterous type series but have not been included in the paratype series because of the possibility that they may pertain to another species.

*Mexicanus* differs from *barozzii* in its smaller size, shorter anteocular portion of the head, shorter hemelytral commissure, and blunt apical connexival angles.

#### ***Cryphocricos hungerfordi*, new species**

*Brachypterous male*.—Elongate, suboval, attenuated anteriorly, over half as wide across abdomen as long, 89 :: 173, the entire dorsal surface covered with a fine white incrustation. Relatively strongly convex above.

Head wider across eyes than long, 31 :: 25, inserted over twice as far into pronotum behind eyes as length in front of eyes to base of labrum, 9 :: 4. Interocular space at narrowest point twice as wide as an eye, 15 :: 7. Labrum two-thirds as long as broad, 17 :: 23, rounded apically. Antennae reaching outer margins of eyes, the proportion of segments one to four as 6 : 6 : 2 : 15.

Pronotum slightly longer than head on median line, 28 :: 25, less than two and one-half times as wide as long, 66 :: 28. Lateral margins relatively finely crenulate throughout, with about 19 rounded projections on each side.

Scutellum less than twice as broad as long, 46 :: 28, and longer than hemelytral commissure, 28 :: 22. Hemelytral margins nearly straight at middle, narrowly rounded basally and broadly rounded apically, but with apical margins only slightly arcuate. Embolium one-ninth the total width of hemelytron, 5 :: 45. Connexival angles of fourth abdominal segment very briefly, bluntly, angulately produced. Genital segments only briefly projecting beyond fourth abdominal tergite.

Front femora slightly wider than length of head, 27 :: 25.

Color brownish ferrugineous throughout except for the fulvous middle and hind legs, the color somewhat obscured by the white incrustation.

*Brachypterous female*.—Very similar to the male except for its size. Median genital plate shallowly biemarginate at apex.

*Macropterous male*.—Very similar to *mexicanus* except for its slightly larger size, more strongly convex upper surface, faint white incrustation,

and more distinctly angulately produced connexival angles of fourth visible abdominal segment.

Pronotum distinctly longer than head on median line, 34 :: 27, less than two and one-half times as wide as long, 82 :: 34, the humeral angles well developed, the lateral margins nearly straight, faintly curved anteriorly and more abruptly so just before eyes. Lateral margins very crenulate except near humeri, with approximately 19 rounded projections on each side.

Scutellum very large, convex, less than twice as wide as long, 60 :: 37.

Hemelytra complete, exceeding tip of fourth abdominal tergite; commissure of clavus less than half as long as scutellum, 15 :: 37. Emboliar suture straight, embolium strongly depressed, its lateral margin rounded at base, feebly concave and slightly divergent posteriorly, rounded to costal margin at apex, the hemelytral margins well within the connexival margins behind embolia.

*Macropterous female*.—Similar to the macropterous male except for genital differences in which it resembles the brachypterous female.

Size: Brachypterous male, length 8.7 mm., width (abdomen) 4.4 mm. Brachypterous female, length 10.2 mm., width (abdomen) 5.3 mm. Macropterous male, length 9.8 mm., width (abdomen) 4.8 mm. Macropterous female, length 10.75 mm., width (abdomen) 5.35 mm.

*Holotype*, brachypterous male, *allotype*, brachypterous female, and *paratypes* as follows: three brachypterous males, four brachypterous females, three macropterous males and four macropterous females, Tantoyuca, Vera Cruz, Mexico, May 5, 1930 (Creaser-Gordon). These specimens were sent from the collection of the University of Kansas through the kindness of Dr. H. B. Hungerford, to whom the species is dedicated. The types have been returned to the University of Kansas.

A single brachypterous female from Concan, Texas, July 6, 1936 (M. B. Jackson) (University of Kansas) apparently belongs here, though it has not been included in the paratype series. This is the first *Cryphocricos* to be recorded from the United States. It agrees structurally with typical *hungerfordi* but the surface is less incrustate.

*Hungerfordi* is closest to *mexicanus*, both structurally and geographically. It differs from *mexicanus* in its larger size, more strongly angulately produced posterolateral angles of fourth visible abdominal segment, slightly wider embolium in brachypterous forms, longer hemelytral commissure in brachypterous forms, and white incrustation.

### ***Cryphocricos obscuratus*, new species**

*Brachypterous male*.—A small, elongate oval species. A little more than twice as long as broad, 131 :: 64. Surface rather uniformly moderately coarsely granulate throughout.

Head transverse, 14 :: 12, the anteocular portion with sides parallel, apical margin truncate, extending beyond the eyes for a distance equal to one-half the transverse width of an eye, less than half as long as postocular portion; antennal proportions, 5 : 5 : 2 : 10. Surface of head moderately convex. Pronotum two and one-half times as broad at base as long on median line, equal in length to head on median line. Lateral margins arcuate throughout, more strongly so anteriorly and posteriorly, coarsely crenulate, especially at middle, with about twelve

rounded projections on each side. Postero-lateral angles evenly rounded, only slightly produced behind level of posterior margin. Scutellum almost twice as broad as long, deeply transversely depressed at base, distinctly longer than hemelytral commissure,  $22 :: 16$ . Hem-

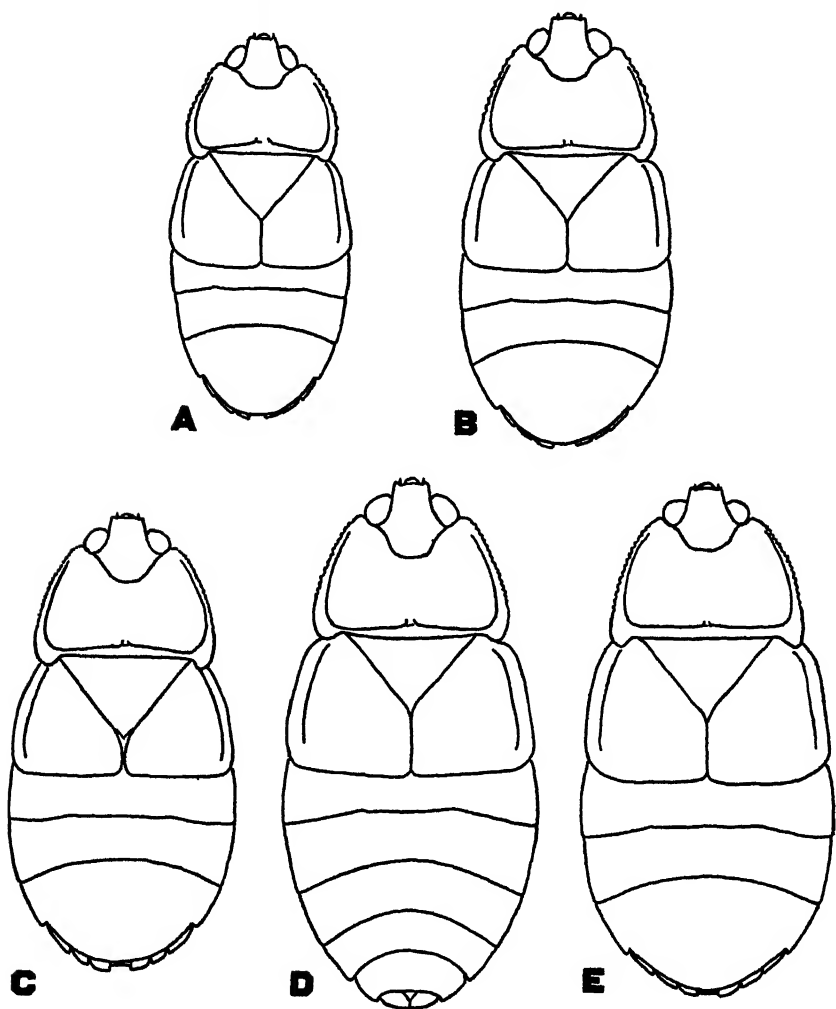


FIG. 2. A. *Cryphocricos obscuratus*, n. sp., male, Panama. B. *Cryphocricos latus*, n. sp., male, Costa Rica. C. *Cryphocricos mexicanus*, n. sp., male, Mexico. D. *Cryphocricos hungerfordi*, n. sp., female, Texas. E. *Cryphocricos hungerfordi*, n. sp., male, Mexico.

elytra covering base of second abdominal segment, sub-truncate at apices, the emboliar margin strongly rounded at base and apex, sub-rectilinear at middle. Embolium one-eighth as wide as total width of hemelytron,  $4 :: 32$ . Connexival angles right angles. Dorsal surface



of abdomen posteriorly conspicuously transversely wrinkled. Front femora robust, about as wide as length of head.

Color obscured by a white incrustation. The ground color evidently brownish-ferrugineous to black with the anterior tibiae and under side more clearly ferrugineous.

*Brachypterous female* with median genital plate narrowly emarginate at middle, appearing as a small notch.

Size: male, length 6.53 mm., width (abdomen) 3.08 mm.; female, length 6.5 mm., width (abdomen) 3.25 mm.

*Holotype*, male. No. 5686, Calif. Acad. Sci., Ent., 6 miles east of Porto Bello, Panama, XX Plantation, February 15, 1930 (T. O. Zschokke). *Allotype*, No. 5687, Calif. Acad. Sci., Ent., and one male *paratype*, same data as type. One nymph relatively broad with well developed hemelytral pads and pronotum.

Several solvents were tried in an attempt to remove the white incrustation which obscures the color of these specimens. None of these was effective so a little of the material was removed from one specimen by scraping. A dark ferrugineous color was revealed beneath.

This species is the smallest known thus far. It differs from *barozzii* Sign. and *breddini* Montd. in the shorter anteocular portion of the head and small size. From *mexicanus* n. sp. it differs in its smaller size, darker color and rounded lateral margins of the pronotum which are more coarsely crenulate. The postero-lateral angles are less strongly produced posteriorly, the disk of the pronotum is without apparent depressions at the middle and the front femora are shorter and stouter.

### *Cryphocricos latus*, new species

*Brachypterous male*.—Elongate-oval, twice as long as broad, 150 :: 74, the surface granulate-incrustate, with finer granules on abdomen than elsewhere.

Head distinctly wider across eyes than long to base of labrum, 30 :: 22, inserted twice as far into pronotum behind eyes as length in front of eyes, 8 :: 4; interocular space at narrowest point half again as wide as an eye, 12 :: 8. Labrum two-thirds as long as broad, 15 :: 23, rounded at apex. Antennae reaching to outer margins of eyes, proportion of segments one to four as 5 : 5 : 2 : 10.

Pronotum slightly longer than head on median line, 25 :: 22, two and one-half times as wide as long, 62 :: 25. Lateral margins rather coarsely crenulate at middle, more finely so anteriorly, with about 16 rounded projections on each side.

Scutellum over twice as broad as long, 43 :: 20, subequal in length to hemelytral commissure, 20 :: 19. Hemelytra feebly arcuate laterally, abruptly rounded at outer apex, slightly curved along apical margins. Embolium one-seventh as wide as total width of hemelytron, 5 :: 36. Connexival angles of fourth abdominal segment abruptly right-angled. Genital segments scarcely projecting beyond fourth abdominal tergite.

Under surface relatively flat. Front femora slightly wider than length of head, 23 :: 22.

Color black above but coated with a white incrustation through which the black granules project; under surface and appendages tinged with reddish brown, the tarsi fulvous and antennae testaceous.

*Brachypterous* female very similar to the male. Median genital plate shallowly, simply emarginate at apex.

Size: male, length  $6\frac{1}{2}$  mm., width (abdomen) 3.7 mm.; female, length 8.1 mm.; width (abdomen) 4.1 mm.

*Holotype*, male, *allotype*, female, and three male and seven female *paratypes*, San Isidro del Gen., Costa Rica, C. A., 2000 feet, February, 1939 (Dean L. Rounds). The holotype and allotype are in the collection of the University of Kansas, paratypes in the University of Kansas and in the collection of the author.

*Latus* is closest to *obscuratus* in all characters, differing from it and other *Cryphocricos* as indicated in the key. *Latus* and *obscuratus* together form a distinctive group of small size, dark color, and heavy incrustation and occur in the adjacent countries, Costa Rica and Panama. Although all the specimens at hand are brachypterous, two nymphs show the well developed hemelytral pads and fully formed pronotum suggestive of the macropterous form.

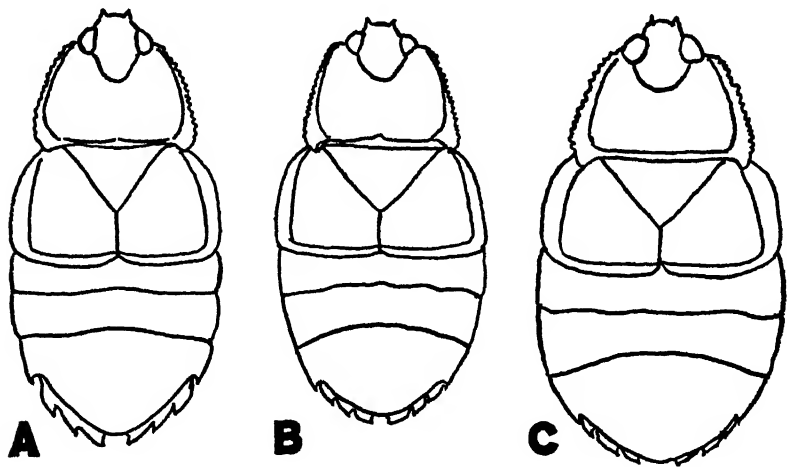


FIG. 3. (After De Carlo.) A. *Cryphocricos daguerrei* De Carlo, male, Argentina. B. *Cryphocricos peruvianus* De Carlo, male, Peru. C. *Cryphocricos rufus* De Carlo, male, Brazil.

### *Cryphocricos breddini* Montandon

*Cryphocricos breddini* Montandon, 1911, Bull. Soc. Sci. Bucarest, 20: 88.

Described from a single macropterous specimen, Balzapamba, Ecuador. I have a specimen from Ecuador, Nov. 1935 (Wm. MacIntyre) which agrees in every particular except for the superficial longitudinal impression on the vertex and shorter anteocular portion of the head (unless Montandon included the jugs and labrum in his measurement). Twenty specimens, including four macropterous specimens, are at hand (University of Kansas) from Peru, one series from Vic. Rio Negro, 790 m., Nov. 4, 1935 (F. Woytkowski) (Field Note 3553 e) and

the other series from Vic Sani Beni, 840 m., July-August, 1935 (F. Woytkowski) (Field Note 3553 b). There is considerable variation in these series, but I cannot distinguish the macropterous specimens from the Ecuador specimen. Brachypterous specimens differ from *barozzii* in that the hemelytral pads are broadly rounded at outer apices. Also they are considerably smaller. They resemble *rufus* De Carlo in the roundness of outer apices of hemelytra but the body is proportionately narrower than in De Carlo's species.

### *Cryphocricos peruvianus* De Carlo

*Cryphocricos peruvianus* De Carlo, 1940, Rev. Soc. Ent. Argentina, 10: 427.

*Cryphocricos peruvianus* De Carlo, 1941, Rev. Soc. Ent. Argentina, 11: 40, fig. 4.

A brachypterous male and female from Peru, (Juan D. Rivas) University of Kansas, agree with De Carlo's description and figure.

### *Cryphocricos barozzii* Signoret

*Cryphocricos barozzii* Signoret, 1850, Rev. Mag. Zool. (2) 2: 290, pl. 4, fig. 10.

Montandon referred to this species on several occasions as being found in Chile and studied a type "communicated by the administration of the K. K. Hofmuseum of Vienna." However, Signoret's species was from "Brésil." De Carlo recorded the species from Argentina, but later described the specimen as a new species, *daguerrei*.

I have two males and two females, all brachypterous, from Nova Teutonia, Brazil, March 11, 1936 (Fritz Plaumann) which agree in size and general coloration with Signoret's original description. Unfortunately, they do not agree in minor details with Signoret's figures but it would appear that these line drawings are somewhat schematic. Certainly the sharply right-angled hemelytral pads and long anteocular portion of the head are not found in any *Cryphocricos* known to me. Final judgment must be withheld until the type has been re-examined.

Also tentatively placed here are seven specimens, all macropterous, from Colombia, Apolinar Maria, from the University of Kansas collection. These are large and relatively broad as in *barozzii* Sign. but cannot be placed accurately without brachypterous specimens.

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SPECIAL PUBLICATIONS, LINGNAN NATURAL HISTORY SURVEY AND MUSEUM.—Twelve papers of this new series, ten of them on insects, were published during 1942 and 1943 at Lingnan University, Canton, China. The first was in press in Canton at the time of Pearl Harbor, and publication was continued without the knowledge of the occupation forces until circumstances forbade. Some of the articles were printed in this medium only because the *Lingnan Science Journal* was being published in the U. S., and communications were cut off. Fortunately, the stocks were not destroyed during the remainder of the war, but since the number of copies printed of some issues was limited, those containing descriptions of new species are being reproduced in the *Lingnan Science Journal*. The three then available, of the four with new species, were reproduced therein in 1945. The titles follow: No. 1, Destructive long-horned beetle borers at Canton, China, 60 pp., 41 figs., J. L. Gressitt; 2, New longicorn beetles from China, VIII, 6 pp., 5 figs., J. L. Gressitt; 3, ditto, IX, 8 pp., 1 pl., J. L. Gressitt; 4, A provisional synopsis of the longicorn beetles of China—Subfamily Cerambycinae, 34 pp., J. L. Gressitt; 5, New tortoise beetles from China, 4 pp., 4 figs., J. L. Gressitt; 6, Notes on beetles of the genus *Sagra*, 8 pp., 2 pls., W. E. Hoffman; 7, New Longicorn beetles from China, X, 10 pp., 1 pl., 2 figs., J. L. Gressitt; 8, A provisional synopsis of the longicorn beetles of China, II—Subfamily Lamiinae, 44 pp., J. L. Gressitt; 9, Bugs or Homoptera: the cicadas, plant hoppers, plant lice, scale insects, and others, 20 pp., 30 pls., W. E. Hoffman; 10, A provisional bird calendar for Canton, China, 10 pp., J. L. and M. K. Gressitt; 11, Lingnan trees: A list of trees growing on Lingnan University campus, 15 pp., W. E. Hoffman (all 1942); and 12, A second species of lima bean leaf-feeder, *Amsacta lactinea* Cr. (Lepidoptera: Arctiidae), 7 pp., Y. W. Djou (1943). The prices range from U. S. \$0.10 to U. S. \$0.50 each.

—J. L. GRESSITT.

# ON THE ODD, OR TISSUE-PAPER, BEETLE SUPPOSED TO BE THYLODRIAS CONTRACTUS

(Coleoptera: Dermestidae)

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This odd scavenger is a minute dermestid beetle breeding annually and subsisting only on dried animal matter, in association with man. It probably degenerated into its present wingless and almost grublike form from a winged, free-living form, and became dependent for survival upon constant replenishment of waste animal food about the permanent den of some predator, perhaps man, in arid, cool-temperate Asia. It is recorded from Tiflis, Transcaucasia 1839, Provinces of Astrakhan and Turkestan 1894, New York 1903, Milwaukee 1908, St. Petersburg, Russia 1909, Egypt 1921, Canada 1932, Chicago 1933, and Texas and Minnesota 1939. It is probably now cosmopolitan but is not so recorded, as few observers recognize its inconspicuous adults. Discrepancies in recorded and actual characters leave its identification as *Thylo-drias contractus* still uncertain, but the names *Ignotus aenigmaticus* and *Hospitopterius efflatouni* have been given to our pest, and the emendation *Thelydrias* was proposed to supplant *Thylo-drias*. More than 40 years' experience with and interest in this museum pest which now infests houses, prompts the following discussion. Adoption of "tissue-paper beetle" as its common name would be unfortunate, since it is based on a misconception arising from the finding of stray individuals crawling onto this conspicuous background from their actual breeding place. Tissue paper seems to be of no importance in its ecology. A bibliography is appended.

*Origin.*—If female degeneracy is so great that eggs can be laid only where the female matures, and if dispersal through larval search for food is also slow and feeble, distribution and survival must depend on agents other than the degenerate species. In very degenerate beetles, such as wingless meloids, female stylopids, etc., dispersal is accomplished by specialized instincts and structures for phoresy (transportation by other animals) in the first-stage larvae. But a degenerate scavenger, in which the female is a wingless grub unable to place her eggs more than a few inches from where her mother matured, would have become extinct unless food for successive generations were replenished. Such replenishment might have been made by an untidy predator leaving wasted food to dry out about its permanent den, thus supplying nutrition for the degenerating scavenger over a vast period of time. Perhaps the untidy predator, about whose den this pest degenerated, was primitive man living in the now arid interior of Asia. Since the pest issues as an adult early in spring, even in heated museums, its home could not have been tropical. The degenerate scavenger here considered first attracted attention in our country in 1902, in New York. It has now been spread by shipment of goods throughout the

country, to become a pest in museums and later in households, but is so seldom recognized that records are not available. Perhaps its recent cosmopolitan dispersal in human habitations is merely reoccupation of its ancestral association.

*Occurrence; flight.*—My interest in this beetle has been continuous since the late E. A. Schwarz showed me the sample of males when he received it from Mrs. A. T. Slosson in 1902. A little later L. H. Joutel sent larvae, females, and males from the same infestation. The first sign of infestation observed in Washington was the presence of cast larval skins in a bird's nest in the National Museum collection about 1919. A year or two later a small box of insects received from F. H. Chittenden was found to be infested. Other infestations came to notice in collections of mollusks and in exhibition cases until by 1928 the species had become commonplace in the Museum. Great surprise at finding a male with fully developed wings led me to confine him with a female freshly emerged from an isolated pupa, and to rear their progeny, among which there developed numerous winged males. This experience was written to M. Pic, who had just named *Hospitopterus* from Egypt as a new genus differing from *Thylodrias* only in having well-developed underwings.

The latest severe infestation was brought to me in March 1946. A box of papered insects from Russia had remained unopened since it was received about 4 years earlier and had reached the climax of its infestation. All of the dried animal matter except the wings had been consumed by larvae of successive annual generations, the last one having transformed into adults. Several hundred of these were active and many others were dead. Numerous eggs had been laid and many full-grown larvae had not yet transformed, but there were no young larvae. The sexes seemed about equally numerous, and about one-fifth of all the males showed fully developed underwings. One large winged male, selected to represent maximum development, ran rapidly over my hand, spread its wings, and escaped by swift flight. Another case of flight by a male of this species was reported to me by John Bowman in Pittsburgh. Record of well-developed underwings, or of ability of males of this species to fly, has not been found in the literature.

These and other experiences demand some disagreement with parts of the carefully prepared article on this species by Petrakis, 1939. One might guess that his very slight success in his attempted rearings might have resulted from his belief that the name "tissue-paper bug"—as he says—"is a good one, and in all the cultures of specimens used for breeding purposes we include a liberal amount of white tissue paper of which the specimens seem to be very fond." In my own opinion all nutriment used by this species is from dried animal matter, and tissue paper, if eaten at all, is merely penetrated as a barrier in the search for food, or fed upon if the larvae are starving. Characteristic of our late friend Wm. T. Davis, and his keen personal interest in his entomological friends and their problems, he maintained cultures of this beetle from Mrs. Slosson's original infestation for 33 years, recording this culture in 1936. Perhaps this culture was from a feeble stock which had lost the ability to produce winged males; otherwise he would have observed and reported them.

*Name*.—By what name shall we call this pest? *Ignotus* has only 9 joints in the antenna (fig. 1, *A*, *B*), as stated by Blanchard (*in* Slosson 1903), whereas 11 joints, differing from those of *Ignotus* in their shapes, are distinctly described and illustrated (fig. 1, *C*, *D*) in the carefully prepared original proposal of the name *Thylo-drias* by Motschulsky, 1839. This difficulty cannot be explained away on any technical grounds unless restudy of the Motschulsky types from Tiflis permits correction of his description and its extension to include also the record of the frontal ocellus and other characters. The miscount of 10 joints by Blanchard (*in* Slosson 1908), 5 years after he had correctly stated

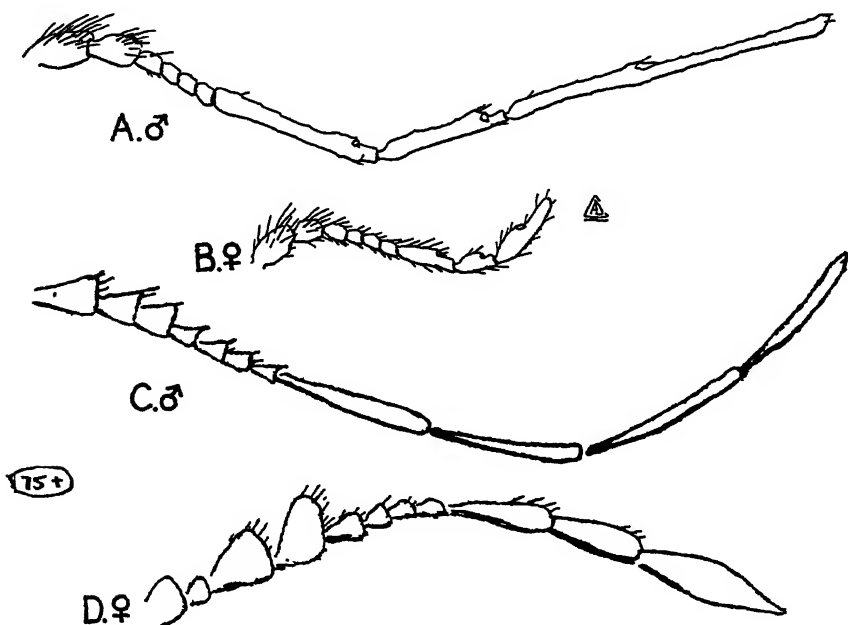


FIG. 1. Is the "odd beetle," *Ignotus*, identical with *Thylo-drias*? A, B. Antennae ♂ ♀ of *Ignotus aenigmaticus* drawn by Arthur D. Cushman. C, D. Antennae ♂ ♀ of *Thylo-drias contractus*, enlarged copies from original illustrations by Motschulsky, 1839.

that there were only 9, is obviously based on misunderstanding of the very elongate 9th, or terminal joint, which is slightly expanded near the middle with a large sensory pore, followed by a constriction resembling an articulation as indicated in the figure. This misinterpretation of joint 9 of the male antenna is shown in the figure by Joutel (*in* Slosson 1908) and in subsequent figures including that by Hinton 1945. *Thylo-drias* was also originally described and illustrated as showing a scutellum in the female, whereas no vestige of such a structure is observable in *Ignotus*. Semenov, 1912, describes male antennae as 10-jointed, female antennae as only 9-jointed, but does not mention Motschulsky's count of 11 nor the original types which are supposed to be in Moscow. But readoption of *Ignotus aenigmaticus* Slosson, 1903, as the name for

our pest would be confusing and only temporary, if the Motschulsky types were found by some colleague in Moscow to demand correction of the original description of *Thylodrias* to agree with our pest. Absence of any formal description led Semenov, 1912, to cite *Ignotus* as if it were invalid until 1908, but Mrs. Slosson's quotations from letters by Liebeck, Blanchard, Fall, and Sharp discuss the 9-jointed antennae, frontal ocellus, form, appearance, and dermestid affinity, and, in my opinion, the name was unintentionally validated in 1903.

Use of the name *Ignotus* was discontinued following the note by Zaitzev, 1909, stating that it was without doubt the species which he knew as *Thelydrias* infesting his home in St. Petersburg.

Pic, 1921, based a new name, *Hospitopterus efflatouni*, on the male from Cairo, Egypt, and in 1931 recorded the female found with males infesting a box of mollusks and pheasant eggs, also in Cairo. All the recorded characters, including the underwings, which he cited as the most important differences from *Thylodrias*, are observable in samples of *Ignotus aenigmaticus* obtained in the recent infestation of the Russian insects in Washington. A wingless male collected in Heluan, 10 miles south of Cairo, in 1894, by A. Fenyes, also agrees with the apterous males in this most recent infestation.

The generic name, *Thelydrias* Agassiz, 1846, requires consideration. Our successors, who will doubtless be predominantly zoologists with even less knowledge of classical Greek than is enjoyed by the present generation, may have a still stronger aversion to arguments for emendation of original spellings of generic names, and especially may oppose the attempted back-dating of these emendations to the original publication date. The spelling *Thylodrias* appears three times in the 1839 paper and was obviously thus spelled to conform with the author's concept of the Greek word which was there printed with its meaning. Motschulsky's error in spelling this Greek word can be understood only by those whose classical training has given them an unusual knowledge of this language, and in spite of attempts to correct this not too obvious error zoologists will continue to find the convenient and pronounceable name *Thylodrias*, instead of *Thelydrias* whenever the basic publication is consulted. It appears to me that Article 25 of the Code is law; Article 19 permits but does not demand emendation, and appendix F is an excellent guide for the formation of new names, but does not require emendation of old names. The contention is between those nomenclaturists having extensive training in classical Greek and the zoologists who are worried, not only by the nomenclature and classification in published literature, but also by the much more complex data available from new specimens and discoveries.

If a restudy of Motschulsky's original types can show that his old description should be corrected to agree with the structure of *Ignotus* the available names would be as follows:

Genus *Thylodrias* Mots., 1839

Syn.—*Thelydrias* Agassiz, 1846

*Ignotus* Slosson, 1903

*Hospitopterus* Pic, 1921

Species *contractus* Mots., 1839

Syn.—*aenigmaticus* Slosson, 1903

*efflatouni* Pic, 1921



But if the original description proves to be correct, our household pest must be a different form, for which the synonymy would seem to be as follows:

Genus *Ignotus* Slosson, 1903

Syn.—*Thelydrias* Zaitzev, 1909, not Agassiz, 1846

*Thylodrias* Leng, 1920, not Motschulsky, 1839

*Hospitopterus* Pic, 1921

Species *aenigmaticus* Slosson, 1903

Syn.—*contractus* Zaitzev, 1909, not Motschulsky, 1839

*efflatouni* Pic, 1921

*Systematic position.*—*Thylodrias* was placed by Motschulsky, 1839, in the Malachiidae, but Reitter, 1894, transferred it into the Drilidae. Reitter's statement that it lives in the roach *Blatta orientalis* suggests that he may have confused it with the parasitic ripiphorid, *Ripidius paradoxus*.

The significance of the frontal ocellus was recognized by Sharp (*in* Slosson 1903), assigning *Ignotus* to Dermestidae. Pic, 1921, mentions this ocellus of *Hospitopterus*, which differs from *Thylodrias* only in the development of hind wings, but in 1927 he places *Pterydrias* near *Thylodrias* in the Drilidae. In the Winkler catalogue, 1925–26, *Thelydrias* is inserted at the end of Drilinae and *Pterydrias* at the end of Karumiinae, on page 542, while *Thylodrias* and *Hospitopterus* are listed in Dermestidae on page 675. Unfortunately all four generic names applied to this pest seem to be omitted from the Junk Catalog. The description of the North African dermestid genus *Seffrania* Pic, 1899 (Bul. Soc. Ent. de France, p. 28), and its figure by Bleuse, 1911 (loc. cit., p. 9), show antennal structures and body form suggestive of a possible ancestor from which our pest may have degenerated. Perhaps the female and larva of *Seffrania*, when found, may corroborate such close relationship. Rees, 1943, accepted *Thylodrias* as closely related to *Apsactus* in the Dermestidae.

P. S.: Fletcher's pleasing story on "The Odd Beetle" from samples infesting the insect collection at the University of Massachusetts appeared while this note is in press and mentions small as well as well developed underwings of males.

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LADYBEETLES OF THE GENUS *EPILACHNA* (SENS. LAT.) IN ASIA, EUROPE AND AUSTRALIA, by G. H. DIEKE. iii 183 pages, 27 plates, January 20, 1947, Smithsonian Miscellaneous Collections, Vol. 106, No. 15.

Evidently the family Coccinellidae is a fertile field for taxonomic work, for this revision, like that of *Hippodamia* also reviewed in this issue, states the need for further extensive studies as a prerequisite of a thorough revision. In *Epilachna* the African and American species are said to require detailed study. The author also notes that some species had to be left out of this study for lack of material, since he has confined himself to material which he could check personally.

The article is strictly taxonomic, barring occasional biological notes, and as such appears to be a very careful and thorough study. Only references to original descriptions are cited, but descriptions of morphology, color and pattern, genitalia, distribution, material studied, and discussion of salient characters are ample and the numerous illustrations are well drawn and well reproduced. The author states that many species of *Epilachna* resemble each other so closely that a key would be of little use.

The genus *Epilachna* is retained for forty-eight of the species treated, among which twenty-five species and fourteen subspecific forms are described as new. A new genus, *Afidenta*, is established for three species including one new species and one new subspecies. The new genus *Afissa* includes fifty species, of which twenty-seven are new. Two new subspecific forms are also described. Finally a new genus, *Epivertia* is established for a single species, *chelonina* (Mader).

The plates are made up of figures of adult maculation and male genitalia with the exception of five halftone plates showing figures of female genitalia.—A. W. L.

## UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES

(Diptera: Tipulidae)

### PART VI

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The preceding part under this title was published in the *Annals of the Entomological Society of America*, 17:431-448; 1924. The majority of the new species herein considered were included in large collections sent to me several years ago by my friend, Professor S. Kariya, to whom I express my thanks for the privilege of retaining the types. Other sources of materials are mentioned under the individual species.

#### Genus *Limonia* Meigen

##### *Limonia* (*Discobola*) *parvispinula* n.sp.

General coloration of mesonotum obscure yellow, the praescutum with a single median brown stripe, the posterior sclerites of the notum chiefly infuscated; pleural dark stripe only vaguely indicated; halteres with the knobs uniformly darkened; blackened rings on femora broad; wings with the usual ocelliform pattern and with additional dots and spots in the cells, chiefly in *M* and *Cu*<sub>1</sub> but also in other cells; male hypopygium with the rostral spines very small and peglike, the margin of the dististyle basad of these strongly corrugated.

*Male*.—Length, about 7.5 mm.; wing, 7.8 mm.

Rostrum and palpi black. Antennae with scape black; pedicel obscure yellowish brown; flagellum black, the incisures pale, including the glabrous apices and the narrower bases of the segments; two outermost segments subequal. Head dark gray, variegated with darker.

Pronotum obscure yellow, slightly darker on sides. Mesonotal praescutum obscure yellow with a single median brown stripe; posterior sclerites of notum brown, the dorsal portion of suture between medio-tergite and pleurotergite paler. Pleura obscure yellow, with very vague indications of a longitudinal pale brown stripe from behind the fore coxae across the dorsal pleurites. Halteres with stem yellow, knob infuscated throughout. Legs with coxae and trochanters yellow, fore coxae a trifle more infuscated; femora yellow, each with a broad black subterminal ring, subequal on all legs and exceeding twice the yellow apex; tibiae and tarsi yellow, the outer tarsal segments infuscated. Wings yellow, with a conspicuous much broken brown pattern, including the usual ocellate markings, with additional abundant brown spots and dots along posterior border of cell *R*, over all of cell *M*, about seven darker spots in an evenly spaced series in cell *Cu*<sub>1</sub>, and less evident scattered dots in most cells beyond the cord; veins obscure yellow, brown in the patterned fields. Venation: *Sc*<sub>1</sub> ending opposite fork of *Rs*, *Sc*<sub>2</sub> a short distance from its tip; *Rs* angulated and weakly spurred at origin;

cell 1st  $M_2$  elongate, exceeding vein  $M_{1+2}$  beyond it;  $m-cu$  at or shortly beyond the fork of  $M$ ; cell 2nd  $A$  narrower than in *moiwana*, the supernumerary crossvein in cell 1st  $A$  subequal to the distal section of vein 2nd  $A$ .

Abdominal tergites pale brown, with long erect pale setae; sternites clearer yellow; hypopygium brownish yellow. Male hypopygium with the tergite transverse, the caudal margin with a broad and shallow notch, the lateral lobes relatively small and obtuse, provided with elongate setae. Basistyle with the ventromesal lobe very broad-based, tapering to the obtuse tip. Dorsal dististyle angularly bent beyond midlength. Ventral dististyle small, its area subequal to that of the ventromesal lobe of the basistyle; rostral portion conspicuous, unusually sclerotized, narrowed to the subacute tip; rostral spines at base of prolongation, very small and peglike; basad of these spines, the outer margin of style strongly roughened or corrugated. Gonapophysis with mesal-apical lobe long and straight.

*Habitat:* Japan (Honshiu). *Holotype*, ♂, Kamikochi, Shinano, altitude 5,000 ft., August 18-21, 1934 (Kariya).

In an early letter from my friend Mr. E. Suenson, a brief account of Kamikochi is given. "The valley between the mountains lies at 5,000 ft., in places marshy, with a growth of *Alnus*, *Salix* and similar water-loving forms. Elsewhere the soil is dryer and on the mountain slopes grow fine forests of big trees, including large birches, a variety of deciduous trees and conifers, including some fine larch trees."

The present fly is most similar to *Limonia* (*Discobola*) *moiwana* (Alexander) of northern Japan, but differs in many details of coloration of the body and wings. In *moiwana*, the supplementary brown pattern is restricted to cell  $M$  and the areas in cell  $Cu_1$  are more extensive and only four in number. The male sex of *moiwana* is still unknown to me..

#### *Limonia* (*Libnotes*) *kariyana* n. sp.

Allied to *regalis*; general coloration of head and thorax brownish gray; antennae black; legs black, only the femoral bases yellow; wings pale yellow, heavily patterned with brown; supernumerary crossveins in cells  $R_3$  and  $R_5$ ; free tip of vein  $Sc_2$  lying more than its own length beyond the level of  $R_2$ ; veins  $R_3$  and  $R_{4+5}$  on their outer portions deflected strongly caudad, ending at or beyond the obtuse wing tip.

*Male*.—Length about 15 mm.; wing, 25 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval, the short verticils at near midlength of the segments, from evident elevated areas; terminal segment elongate, its distal half suddenly narrowed. Head dark brownish gray; anterior vertex reduced to a narrow line, approximately one-fourth as wide as the diameter of scape.

Pronotum dark brownish gray, the extreme posterior portions and the adjoining part of praescutum obscure yellow. Mesonotum dark brownish gray, the praescutum with three confluent darker brown stripes that chiefly cover the disk; a darker area near side of praescutum behind the pseudosutural foveae; posterior sclerites of notum brownish black, sparsely pruinose. Pleura brownish black, sparsely pruinose, the pleurotergite and posterior anepisternum a trifle paler. Halteres with

stem and apex of knob obscure yellow, the base of the latter weakly darkened. Legs with fore coxae and trochanters abruptly yellow, remaining coxae brownish black, sparsely pruinose, trochanters obscure yellow; remainder of legs black, the femoral bases restrictedly obscure yellow, including about the proximal fourth; claws with a major tooth at near midlength and a series of about six smaller denticles on proximal half; vestiture of femora short and spiniform. Wings with the ground color pale yellow, the prearcular, costal and stigmal fields clear butter-yellow; a conspicuous brown pattern, appearing as seams to the veins and crossveins, most evident along the cord, outer end of cell 1st  $M_2$  and over the supernumeraries, reaching the costal border at the free tip of  $Sc_2$ ; a broad seam along vein  $Cu$ ; less evident darkenings on parts of outer radial and medial veins; wing tip and all of posterior border of wing narrowly seamed with brown; veins  $R$  and 1st  $A$  unpatterned, vein 2nd  $A$  again seamed with brown; spots at fork of  $Sc$ ,  $R_3$  and free tip of  $Sc_2$  darker brown; veins brownish yellow, darker in the patterned areas, somewhat paler in the three more infuscated spots. Costal setae short and spiniform; wing tip (male) obtuse. Venation:  $Sc$  long,  $Sc_1$  ending nearly opposite the first section of  $R_{2+3}$ ,  $Sc_2$  at its extreme tip; free tip of  $Sc_2$  lying more than its own length beyond  $R_3$ , bent at about a right angle into costa; supernumerary crossveins in cells  $R_3$  and  $R_5$ , the latter slightly more proximad, the whole series of crossveins and deflections forming a secondary cord at near three-fourths the wing length; both veins  $R_3$  and  $R_{4+5}$  bent very strongly caudad on their outer portions, both terminating at or beyond the wing tip;  $m-cu$  about its own length beyond the fork of  $M$ ; vein 2nd  $A$  elongate, gently sinuous beyond the basal arcuation.

Basal abdominal tergites brown, vaguely patterned with yellow; basal sternites clear yellow, the sides conspicuously dark brown; fifth to eighth segments more uniformly blackened to form a broad subterminal ring; hypopygium abruptly yellow.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Ontake, Hida, southern Alps, altitude 5,850 ft., July 6-10, 1934 (H. Ise); through Kariya.

I take pleasure in naming this species for Professor S. Kariya. This striking and beautiful fly needs comparison only with *Limonia* (*Libnotes*) *regalis* (Edwards), of Formosa. It is well distinguished by the coloration, including the almost uniformly darkened head and thorax and the blackened legs. This species and the next are almost the largest known members of the great genus *Limonia* Meigen.

#### *Limonia* (*Libnotes*) *ingentissima* n. sp.

Size very large (wing, male, 25 mm.); head and thorax almost uniformly plumbeous gray, the praescutum with three brown stripes, the central one broad; halteres elongate, stem yellow, knob dark brown; legs yellow, the tips of the femora broadly and abruptly blackened; wings obtuse at tip, yellow, restrictedly patterned with brown, the areas restricted to the veins; free tip of  $Sc_2$  about its own length before vein  $R_3$ ; cell 1st  $M_2$  widened outwardly,  $m$  angularly bent at near midlength, longer than the basal section of  $M_3$ ; vein 2nd  $A$  relatively long, gently sinuous beyond the arcuated base; abdominal tergites and sternites yellow, trivittate with brown, segments six to eight brownish black; hypopygium yellow.

*Male*.—Length about 17 mm.; wing, 25 mm.

Rostrum and palpi black. Antennae with scape and pedicel light brown, the former sparsely pruinose above; flagellum brown; basal flagellar segments short-oval, constricted at the incisures, the outer segments more elongate; terminal segment long, pointed on distal half; longest verticils subequal in length to the segments, unilaterally distributed. Head gray, more yellow pollinose on the anterior vertex, the latter very narrow, elevated into a ridge between the eyes, continued caudad onto the posterior vertex and becoming bifid behind (this condition possibly due to drying).

Pronotum brownish gray. Mesonotal praescutum light gray, with three relatively indistinct brown stripes, the median one broad, constricted at near midlength, behind more expanded and weakly split by a ground line; lateral stripes less distinct; posterior sclerites of notum more plumbeous gray, the postnotum clear gray pruinose. Pleura plumbeous gray; dorsopleural membrane yellow. Halteres elongated, stem pale yellow, knob dark brown. Legs with all coxae and trochanters light yellow; femora yellow, the tips broadly and abruptly black, subequal on all legs and occupying about the outer eighth of the segment; tibiae yellow, the tips more narrowly infuscated, somewhat more conspicuous on the fore legs; tarsi yellow, the outer segments infuscated; vestiture of femora short and spinous; claws with a conspicuous tooth at near midlength and with about five smaller denticles on basal half. Wings yellow, the prearcular and costal fields deeper yellow; a brown pattern that is restricted to the vicinity of the veins, including seams at origin of  $R_s$ , over the cord and outer end of cell *1st M*<sub>2</sub>; free tip of  $Sc_2$  and  $R_2$ ; along vein  $Cu$  in cell *M*, becoming more extensive on the distal section; outer third of vein *2nd A* and the axillary border; veins light brown, those near base and in the brightened fields clear yellow, in the infuscated areas becoming dark brown. Wing tip very obtuse; costal vestiture short and dense. Venation:  $Sc_1$  ending about opposite one-third the length of cell *1st M*<sub>2</sub>,  $Sc_2$  a short distance from its tip; free tip of  $Sc_2$  about its own length before vein  $R_2$ , the latter perpendicular but curving into  $R$ ; both veins  $R_3$  and  $R_{4+5}$  bent very strongly caudad at outer ends, terminating at or beyond the wing tip; cell *1st M*<sub>2</sub> widened outwardly,  $m$  angularly bent at near midlength, longer than the basal section of  $M_3$ ;  $m-cu$  oblique, about its own length beyond the fork of *M*; vein *2nd A* relatively long, gently sinuous beyond the arcuated base.

Abdomen with basal segment dark brown, sparsely pruinose; succeeding tergites yellow, with three more or less distinct brown stripes, on the outer segments the median one becoming very delicate and restricted to the proximal half of the segment; basal sternites more obscure yellow, similarly trivittate with brown; segments six to eight, inclusive, uniformly brownish black to form a conspicuous ring; hypopygium yellow.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Kamikochi, Shinano, altitude 5,000 ft., September 8, 1935 (E. Suenson).

This large and striking fly is most similar to the smaller *Limonia* (*Libnotes*) *nohirai* (Alexander), differing not only in the size and coloration of the body but in the obtuse wing tip and in all details of venation. *L. (L.) regina* (Alexander) is more distantly related.

Genus *Dicranota* Zetterstedt*Dicranota* (*Dicranota*) *sicaria* n. sp.

Size relatively large (wing, male, 7 mm. or more); antennae short; general coloration of entire body gray, the praescutum with four dark brown stripes; wings with a weak brownish tinge, stigma conspicuous, darker brown; male hypopygium with the tergite scarcely produced medially, the lateral arms pale, expanded at tips; interbase a strong lobe, obliquely truncated at apex and further produced into a strong spine; dististyle small, broadly flattened.

*Male*.—Length, about 6.5–7 mm.; wing, 7–8 mm.; antenna, about 0.8–0.9 mm.

Rostrum gray; palpi black. Antennae short, 12-segmented; basal flagellar segment oval, the succeeding ones passing into short-oval, the outermost again more elongate; verticils relatively short. Head dark brown, broadly gray in front and on the broad orbits.

Pronotum gray, weakly more darkened on central portion. Mesonotum gray, the praescutum with four conspicuous dark brown stripes, the intermediate pair separated only by an obscure brownish gray capillary vitta; scutal lobes patterned with somewhat more grayish brown. Pleura gray. Halteres with stem whitened, knob a trifle darker. Legs with the coxae dark, gray pruinose; trochanters brownish black; remainder of legs black, the femoral bases obscure yellow. Wings with a very weak brownish tinge, the prearcular and costal fields clearer yellow; stigma darker brown, conspicuous; a vague to scarcely indicated brown tinge over the cord; veins brown, more yellowed in the brightened fields. Venation:  $Sc_1$  ending opposite or just beyond the supernumerary crossvein in cell  $R_1$ ;  $Rs$  oblique, variable in length and steepness;  $R_{2+3+4}$  short to very short, subequal to or shorter than the basal section of  $R_5$ ; cell  $M_1$  present; cell  $M_2$  open by the atrophy of  $m$ ;  $m-cu$  more than one-half its length beyond the fork of  $M$ .

Abdomen, including hypopygium, dark gray, the caudal borders of the intermediate tergites a trifle paler. Male hypopygium with the median region of the tergite only vaguely produced, the lateral arms long and conspicuous, pale, the tips more expanded and bent slightly mesad. Basistyle with apical lobes provided with setae, lacking spinous points. Interbase distinctive, appearing as a strong lobe, its apex obliquely truncated and farther produced into a long straight daggerlike spine; the truncated apex with abundant delicate setulae surrounding the base of spine. Dististyle relatively small, subequal in size to the lesser lobe of the basistyle, broadly flattened, with several strong setae near the obtuse apex; on face of style with a flattened plate or flange.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Hamasaka, Hyogo, April 1, 1931 (*J. Okada*). *Paratopotypes*, ♂♂.

*Dicranota* (*Dicranota*) *sicaria* is quite distinct from the two most similar regional species of the subgenus, *D. (D.) nipponica* Alexander and *D. (D.) yezoensis* Alexander. All details of structure of the male hypopygium are distinctive, particularly the tergite, interbase and dististyle.

*Dicranota* (*Rhaphidolabis*) *macracantha* n. sp.

Allied to *spina*; general coloration of thorax gray, the scutellum and adjoining sclerites conspicuously yellow; halteres uniformly pale yellow;

wings with a milky tinge, the stigma scarcely indicated; veins pale;  $R_{2+3+4}$  scarcely evident, cell  $R_3$  nearly sessile; male hypopygium with the median area of the tergite produced into a broad conspicuous lobe, the lateral arms extended into long powerful spines; interbase a broad yellow blade, narrowed and strongly bent toward tip and here with both dorsal and lower flanges or crests, the former higher and with its margin microscopically serrulate; dististyle dusky, in length nearly equal to the longest lobe of the basistyle.

*Male*.—Length about 5.5 mm.; wing, 0.8 mm.

Rostrum brown; palpi brownish black. Antennae brownish black, short (the number of segments cannot be determined from the available material); flagellar segments oval, with relatively short verticils. Head dark brownish gray.

Pronotum brownish gray, more yellowed behind. Mesonotum brownish gray, the praescutum with indications of a median darker stripe and less evident lateral ones; median region of scutum, the scutellum and cephalic portion of mediotergite yellow; posterior part of mediotergite darkened, pleurotergite yellow on posterior border, slightly pruinose in front. Pleura chiefly pale brownish yellow, the surface sparsely pruinose, especially the more dorsal sclerites; ventral sternopleurite weakly darkened. Halteres uniformly pale yellow. Legs with the coxae and trochanters yellow; femora yellow basally, weakly darkened outwardly; tibiae and tarsi obscure brownish yellow, the outer tarsal segments more darkened. Wings with a milky tinge, particularly at base, stigma scarcely darkened; veins brownish yellow, relatively inconspicuous against the ground. Venation:  $R_{2+3+4}$  barely evident as an unusually short element, cell  $R_3$  sub sessile to virtually sessile; cell  $M_2$  open; *m-cu* very oblique, about one-half its length beyond the fork of *M*.

Abdomen dark brown, the pleural region somewhat paler; hypopygium brownish yellow. Male hypopygium with the tergite large, its median area produced into a broad lobe, the apex subtruncate; surface with numerous setae; lateral tergal arms appearing as strong sinuous spines that are fully three times as long as the median lobe, gradually narrowed to the acute tips. In *spina*, the median tergal lobe is broader and lower and the lateral arms are represented by short slender spines. Interbase a broad yellow blade, narrowed and strongly bent outwardly, terminating in an acute spine, before apex with distinct flanges on both the outer and inner margins, the dorsal crest higher and with the margin microscopically serrulate. In *spina*, such crests are lacking. Dististyle dusky, nearly equal in length to the longest lobe of the basistyle, gradually narrowed to the obtuse tip, the latter with three stronger spinous setae.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Kamikochi, Shinano, altitude 5,000 ft., August 18–21, 1934 (Kariya).

The present fly is generally similar to *Dicranota* (*Rhaphidolabis*) *spina* Alexander (Alpine districts of Hokkaido and Honshiu) from which it differs most conspicuously in the structure of the male hypopygium, as compared above.

***Dicranota* (*Rhaphidolabis*) *ontakensis* n. sp.**

Size large (wing, male, 7 mm. or more); general coloration of thorax gray, the praescutum with three brownish stripes; antennae 14-seg-



mented, black throughout; wings with a milky tinge, the stigma very pale brown; vein  $R_{2+3+4}$  present, varying from short to long; cell  $M_2$  open; male hypopygium with the ninth tergite produced into a depressed bilobed median plate; interbase produced into two slender spines; apex of basistyle produced into a large clavate head that is densely clothed with short spinous setae; dististyle a narrow yellow blade.

*Male*.—Length about 6.5–7 mm.; wing, 7–7.5 mm.; antenna about 1.0 mm.

*Female*.—Length about 7–7.5 mm.; wing, 8–8.5 mm.

Rostrum black, sparsely pruinose; palpi black. Antennae black throughout, 14-segmented; flagellar segments oval, distinct, not at all crowded, the outer ones gradually smaller. Head light gray; anterior vertex wide.

Pronotum dark gray. Mesonotum gray, the praescutum with three more brownish stripes, the broad median one entire in front, very shallowly divided behind; scutal lobes less evidently patterned. Pleura dark gray, the dorsopleural membrane more buffy. Halteres with the stem pale yellow, the apex of knob weakly darkened. Legs with the coxae gray pruinose, paling to obscure yellow at tips; trochanters obscure yellow; femora obscure brownish yellow basally, passing into brown; tibiae and tarsi gradually darker brown to black. Wings with a milky tinge, the prearcular and costal fields more yellowed; stigma scarcely evident as a pale brown cloud; veins brownish yellow, clearer yellow in the brightened fields. Venation:  $R_s$  arcuated to more or less angulated;  $R_{2+3+4}$  present but variable in length, in cases shorter than the basal section of  $R_s$ , in other specimens twice as long as this element;  $R_2$  oblique; cell  $M_2$  open by the atrophy of  $m$ ;  $m-cu$  oblique, from one-third to one-half its length beyond the fork of  $M$ .

Abdomen dark brown or brownish gray, the sternites a trifle more yellowed on their central portions, more infuscated on sides. Male hypopygium very distinctive. Ninth tergite produced medially into a flattened-depressed plate that splits at tip into two oval lobes separated by a deep U-shaped notch, each lobe densely provided with setae; no lateral tergal arms. Basistyle with interbase a glabrous flattened blade that terminates in two acute slender spines; apex of basistyle produced into a large clavate head that is evenly and densely clothed with short dark spinous setae. Dististyle a narrow yellow blade that is more than five times as long as its width at midlength, the tip obtusely rounded; surface of style with sparse elongate setae at base, short peglike setae over much of the outer half, and a few erect or retrorse stronger setae just before apex.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Ontake, Hida, southern Alps, altitude 5,850 ft., July 6–10, 1934 (H. Ise); through Kariya. *Allotopotype*, ♀; *paratopotypes*, 1 ♂, 2 ♀.

The present fly is one of the most distinct species in the entire subgenus. The structure of the male hypopygium is so distinctive in all its parts that it scarcely seems necessary to make comparisons with other forms. In the conformation of the ninth tergite, it most approaches species such as *Dicranota (Raphidolabis) biloba* Alexander, but even here the two structures are not very similar.

Genus *Limnophila* Macquart*Limnophila* (*Phylidorea*) *hokkaidensis* n. sp.

Size very large (wing, female, over 13 mm.); general coloration of head and thorax gray; halteres yellow throughout; femora yellow basally, the tips blackened, very broadly so on the fore legs, narrowest on the posterior pair; wings brownish yellow, stigma dark brown; a restricted paler brown pattern over the cord, *Cu* and vein *2nd A*; *Rs* long, approximately twice the long, nearly straight  $R_{2+3+4}$  or three times *m-cu*; *m* very short; cell  $M_1$  subequal in length to its petiole; *m-cu* at near one-third the length of cell *1st M*<sub>2</sub>; abdomen brownish black; valves of ovipositor reddish horn-color.

*Female*.—Length about 15 mm.; wing, 13.3 mm

Rostrum dark gray; palpi black. Antennae almost uniformly blackened throughout, the extreme base of the first flagellar segment brightened; first flagellar segment cylindrical, the succeeding three short-cylindrical, the remainder much more slender, elongate-cylindrical; verticils of the dilated basal segments unilaterally arranged on outer face, on the outer segments much longer, exceeding the segments in length and occurring on all faces. Head dark gray; anterior vertex very wide, nearly five times the diameter of the scape.

Pronotum large, light gray pruinose. Mesonotum gray, clear light gray pruinose on outer sclerites, the praescutum with indications of three darker grayish brown stripes; pseudosutural foveae very large, dark-colored, suboval in outline; tuberculate pits elongate, near the extreme cephalic portion of praescutum. Pleura heavily gray pruinose over a black ground; dorsopleural membrane light brown. Halteres yellow throughout. Legs with the fore coxae brownish black, heavily gray pruinose, the remaining coxae reddish with a more sparse pruinosity; trochanters yellow; femora yellow, the tips broadly and conspicuously blackened, broadest on the fore pair where nearly the outer two-thirds is included, narrower on the other legs, on the middle pair including about the distal half, on the posterior femora about the distal fifth; tibiae brownish black, the posterior pair a little brighter, brown, the tip narrowly blackened; tarsi black. Wings brownish yellow, the prearcular and costal fields clearer yellow; stigma relatively small, dark brown; a restricted paler brown pattern, as follows: Along cord and at wing-apex; *Cu* and vein *2nd A*; veins brown, yellow in the brightened fields. Venation: *Sc* long,  $Sc_1$  ending about opposite midlength of  $R_{2+3+4}$ ,  $Sc_2$  at its tip; *Rs* long, approximately twice the long  $R_{2+3+4}$  or three times *m-cu*;  $R_{2+3+4}$  nearly straight, subequal to  $R_{2+3}$ ;  $R_3$  and  $R_{1+2}$  subequal in length; basal section of  $R_5$  long, gently arcuated; cell *1st M*<sub>2</sub> subrectangular, a little narrowed at outer end; *m* very short to almost punctiform, the basal section of  $M_3$  correspondingly long; cell  $M_1$  subequal to its petiole; *m-cu* about one-half its length beyond the fork of  $M$ , at near one-third the length of cell *1st M*<sub>2</sub>; vein *2nd A* sinuous on distal half.

Abdomen brownish black, including the genital shield; valves of ovipositor reddish horn-color; cerci very deep at base, short but slender outwardly.

*Habitat*: Japan (Hokkaido). *Holotype*, ♀, Sapporo, June 24, 1932 (Tagawa); through Kariya.

Readily distinguished from all other regional species of the subgenus by the very large size and the details of venation, especially the long *Rs*. In the Nearctic fauna, it is most similar to *Limnophila* (*Phylidorea*) *aleutica* Alexander and *L. (P.) fratria* Osten Sacken, yet entirely distinct. The most similar Palaearctic form is perhaps *L. (P.) squalens* (Zetterstedt), with a wide range over Europe, eastward to Eastern Siberia; this latter is entirely distinct from the present fly and may not belong to this subgenus. All of these species are very much smaller than the present fly.

### Genus *Elephantomyia* Osten Sacken

#### *Elephantomyia* (*Elephantomyia*) *palmata* n. sp.

Allied to *dietziana*; general coloration black, heavily gray pruinose to produce a more or less distinct plumbeous appearance; wings with a weak brownish tinge, heaviest at stigma and in the costal region; abdominal tergites bicolored, the sternites more restrictedly so; male hypopygium with the gonapophyses conspicuously expanded and provided with more than fifteen spines to produce a palmate appearance.

*Male*.—Length, excluding rostrum, 7.5–8 mm.; wing, 9–10 mm.; rostrum, 7–8 mm.

Rostrum about equal in length to the entire body, brownish black. Antennae with scape and pedicel dark brown, flagellum paler. Head dark.

Pronotum black, more or less pruinose. Remainder of thorax almost uniformly blackened, gray pruinose, to produce a more or less plumbeous appearance, the scutellum a little paler; dorsopleural membrane pale yellow. Halteres uniformly pale yellow. Legs with the coxae yellow, the posterior pair clearer; trochanters yellow; femora obscure yellow basally; the outer portions of the fore pair broadly dark brown, involving the outer two-thirds or more; remaining femora with the tips much more narrowly infuscated, including about the outer seventh or eighth; tibiae and tarsi brownish yellow to yellow. Wings with a weak brownish tinge, the costal border and stigma somewhat darker brown; prearcular field yellowed; veins brown, yellow in the prearcular field. Venation: *Sc*<sub>2</sub> ending just beyond the fork of *Rs*, longer than the subatrophied *Sc*<sub>1</sub>; anterior branch of *Rs* sinuous, generally parallel to the posterior branch; cell 1st *M*<sub>2</sub> a little longer than vein *M*<sub>4</sub>; *m-cu* a little longer than the distal section of *Cu*<sub>1</sub>, placed just beyond midlength of cell 1st *M*<sub>2</sub>.

Abdomen indistinctly bicolored, chiefly dark brown to brownish black, the basal rings of the intermediate segments yellow, broadly so on the tergites, especially segments four to seven, inclusive, where more than the proximal third is so brightened, very narrowly and indistinctly yellowed on the bases of the intermediate sternites, especially segment five; outer segments and hypopygium uniformly blackened. Male hypopygium with the mesal face of basistyle with abundant setae, those near the cephalic portion longer and more conspicuous; outer face of

basistyle with relatively few setae. Dististyles apical in position, the outer shorter, slender, the apical spine strongly curved, the outer subapical point small and straight. Inner dististyle with outer half slender. Gonapophyses unusually broad, palmate, provided with more than fifteen conspicuous spines. Aedeagus coiled.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Ontake, Hida, southern Alps, altitude 5,850 ft., July 6-10, 1934 (H. Ise); through Kariya. *Paratopotypes*, 2 ♂♂.

There are various species in the Palaearctic region that center around *Elephantomyia* (*Elephantomyia*) *dietziana* Alexander. This latter fly has the dististyles apical in position and with the gonapophysis produced into a long pale point, the outer portion much reduced in area and with fewer than ten spines. The European *E. (E.) edwardsi* Lackschewitz is quite distinct from both *dietziana* and *palmata* in the subterminal dististyles and in the armature of the gonapophyses. *E. (E.) hokkaidensis* Alexander, of northern Japan, belongs to an entirely different group of species, being more nearly allied to the genotype, *E. (E.) westwoodi* Osten Sacken, of the Nearctic region, the gonapophyses being without spinous points.

#### Genus *Cladura* Osten Sacken

##### *Cladura daimio* n. sp.

Belongs to the *megacauda* group; general coloration yellow; tips of femora narrowly infuscated; abdominal tergites yellow, trivittate with pale brown, the median stripe more distinct and continuous; male hypopygium with the outer lobe of basistyle and the dististyle subequal in length, the latter large, expanded outwardly, the apex vaguely bilobed; lobe of mesal face of basistyle a large flattened setiferous blade.

*Male*.—Length, about 8 mm.; wing, 9.5 mm.

*Female*.—Length, about 8.5 mm.; wing, 9.5 mm.

Rostrum and palpi yellow. Antennae yellow, the bases of the flagellar segments weakly darkened; verticils conspicuous. Head yellow.

Thorax uniformly yellow, the surface polished or subnitidous, with conspicuous long pale setae on the praescutal interspaces and elsewhere. Halteres pale, the knobs very slightly darker. Legs yellow, the extreme tips of the femora infuscated; outer tarsal segments brown. Wings pale yellow, the prearcular and costal fields a trifle more saturated; veins brown. Venation:  $R_2$  tending to become evanescent;  $R_{1+2}$  a trifle less than  $R_{2+3+4}$ ; cell  $1st\ M_2$  small, about as long as vein  $R_{2+3+4}$ ;  $m$  about one-half the petiole of cell  $M_1$ .

Abdominal tergites yellow, rather distinctly trivittate with pale brown, the median stripe especially distinct and continuous; posterior borders of tergites narrowly pale; sternites yellow, the caudal borders and especially the outer lateral angles of the same darkened; hypopygium yellow. Male hypopygium as in *megacauda*, differing in all details of the basistyle and dististyle. Details of tergite not clearly evident in the single available male. Outer lobe of basistyle slender, gradually narrowed to the tip, provided with scattered setae, those at

apex forming a sparse but conspicuous brush. Dististyle as long as the lobe of basistyle and larger, narrow at base, expanded outwardly, the tip vaguely bilobed. Basistyle with proximal end of mesal face produced into a large flattened blade, the apex truncated, the surface with abundant setae; caudal portion of this blade further produced into a flattened oval lobe.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Morioka, October 6, 1934 (T. Kato). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 2 broken specimens. Associated with *Cladura megacauda* Alexander.

I am restricting the term *megacauda* group to the three species herewith discussed, all having the outer angle of the basistyle of the male hypopygium greatly produced beyond the point of insertion of the dististyle. All three species are most readily distinguished by their hypopygial characters. *Cladura alpicola* Alexander has the lobe of the basistyle unusually long and slender; dististyle of peculiar shape, produced at base into a strong obtuse lobe; the basistyle itself is very slender, its mesal lobe having a distinctive shape. *C. megacauda* Alexander is again very different, the dististyle being a trifle longer than the outer lobe of the basistyle, narrowed outwardly, the tip obtuse, with a dense cushion of relatively short setae; mesal lobe of basistyle unusually small and slender, again of peculiar shape. Earlier (Philippine Journ. Sci., 40: 342; 1929) I had considered that the members of the group possessed two dististyles but it is now evident that the outer one of these is actually a long outer prolongation of the basistyle, subequal in length to or exceeding the dististyle itself. This condition is unique among the various species of *Cladura* now known and may possibly be held as being of subgeneric value. It should be noted that *Crypteria* Bergroth and *Neolimnophila* Alexander actually do have two dististyles.

#### *Cladura alpicola setuliloba* n. subsp.

*Male*.—Length, about 7.5 mm.; wing, 8.8 mm.

Characters as in the typical subspecies (Japanese Alps, Honshiu: Yurigatake), differing especially in hypopygial characters.

Venation with the petiole of cell  $M_1$  short to very short, less than  $m$ . Male hypopygium with the lateral lobes of the ninth tergite broader and more or less incurved. Basistyle with the lobe of mesal face even larger, the lateral fingerlike lobule more pointed and with only two or three long setae at extreme tip; almost the entire surface of lobe densely setuliferous, more abundant and conspicuous than in the typical form. Outer lobe of basistyle broken in the unique type. Dististyle with the basal lobe longer and stouter, approximately two-thirds the length of the rostral blade and much stouter.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Mt. Myotaka, August 1, 1923 (Fuzimatsu); through Kariya.

#### *Cladura taiwania* n. sp.

*Cladura decem-notata* Alexander; Philippine Journ. Sci., 40: 540; 1929; not *C. decem-notata* Alexander, Ann. Ent. Soc. America, 17: 436–437; 1924.

*Cladura decem-notata* was described from the island of Kiushiu. Later I discussed the species briefly and indicated the possibility that the Formosan material represented a distinct species, a fact of which I am now more firmly convinced. I have withheld the description of the present fly while awaiting the receipt of male specimens of the true *decem-notata*. No further materials have become available and I am describing the species on the basis of the original specimens.

*Male*.—Length, about 6.5–7 mm.; wing, 8.5–9 mm.

Compared with *decem-notata*, the dark spots on the mesonotal praescutum are larger, particularly the anterior pair and those on the scutal lobes; darkening on the ventral sternopleurite likewise more extensive. Abdominal tergites more uniformly infuscated, the individual segments with very narrow pale posterior borders. In *decem-notata*, the central portion of the abdominal tergites is broadly yellow, the sides abruptly infuscated. Wings clearer yellow, the veins paler, more delicate, and relatively inconspicuous against the ground. Venation:  $Sc_1$  ending opposite the fork of  $R_{2+3+4}$ ;  $Rs$  strongly arcuated at origin;  $R_{2+3+4}$  longer than cell 1st  $M_2$ ; petiole of cell  $M_1$  longer than  $m$ . Male hypopygium with the mesal face of basistyle provided with abundant long setae. Disistyle very large, terminal in position, narrow at base, widely expanded outwardly to appear more or less triangular in outline, the apex broadly emarginate; cephalic or inner lobe fringed with a row of strong setae that are angularly produced at tip into a slender hairlike point. Gonapophysis relatively small and inconspicuous. Aedeagus dilated at near midlength, the distal third slender.

*Habitat*: Formosa. *Holotype*, ♂, Shorei, altitude 7000–8000 ft., October 25, 1928 (S. Issiki). *Paratopotypes*, 7 ♂♂.

#### *Cladura tetraspila* n. sp.

General coloration yellow, the mesonotum with four conspicuous brown spots, including two each on the praescutum and scutum; wings unpatterned; male hypopygium with the median region of the tergite produced caudad into a flattened plate, its margin with a rounded notch; basistyle unarmed; dististyle apical in position, profoundly bifid; gonapophysis appearing as a broadly flattened blade, the apex with abundant spinous points; aedeagus with a lateral flange that is microscopically papillose.

*Male*.—Length, about 6 mm.; wing, 7.5 mm.

*Female*.—Length, about 7–7.5 mm.; wing, 8–9 mm.

Rostrum yellow; palpi a little darker, especially the outer segments. Antennae 15-segmented; scape and pedicel yellow, flagellum weakly bicolored, yellow, the bases of the segments slightly more darkened; outer segments weakly pale brown; fusion-segment involving two segments. Head uniformly yellow, with a very sparse bloom.

Mesonotum yellow, with four conspicuous dark brown spots, including two on the posterior portions of the praescutum, representing the usual lateral stripes, the second pair on the scutal lobes; remainder of notum and the pleura yellow. Halteres yellow. Legs yellow, the extreme tips of the femora and tibiae infuscated; tarsi dark brown, the proximal portion of the basitarsi obscure yellow. Wings yellow, more brightened in the prearcular and costal fields; stigmal area a trifle

differentiated by a more yellowish suffusion; veins brown, yellow in the more brightened fields. Venation:  $Sc_1$  ending nearly opposite the fork of  $R_{2+3+4}$ ,  $Sc_2$  about opposite two-thirds the length of the latter;  $R_{2+3}$  subequal in length to  $R_{2+3+4}$  or  $R_{1+2}$ , or, in cases, with  $R_{2+3}$  longer; petiole of cell  $M_1$  nearly twice  $m$ ;  $m-cu$  from about one-fourth to nearly one-half its length beyond the fork of  $M$ .

Abdominal tergites brown, sternites yellow; a subterminal more blackened ring; hypopygium obscure yellow. Male hypopygium of moderate size; region of tergite produced into a median paler plate, the caudal border of which bears a rounded notch, the lateral lobes thus formed unequally bilobulate, the inner lobule more truncated at apex, the outer lobule or shoulder rounded. Basistyle relatively slender, without armature. Dististyle apical in position, profoundly bifid, forming two relatively slender arms; inner arm narrowed at apex into an acute point, the entire surface with abundant long pale setae; outer arm a little dilated just before apex, thence narrowed to the tip, the setae restricted to this outer portion. Each gonapophysis appearing as a broad flattened blade, the apical margin with numerous spinous points, including a larger outer spine. Aedeagus short, subtended by a flange that is microscopically papillose.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Gora, Hakone District, November 11, 1931 (Sawada). *Allotopotype*, ♀. *paratopotype*, 1 ♀.

*Cladura tetraspila* is readily distinguished from the other species having variegated thoraces, including *C. decem-notata* Alexander, *C. machidella* Alexander, and *C. taiwania* sp. n., by the nature of the pattern. It is further told from all species of the genus where the male sex is known by the somewhat peculiar hypopygium, particularly the profoundly bifid terminal dististyle.

#### *Cladura hakonensis* n. sp.

General coloration of thorax brownish gray, conspicuously gray pruinose, especially on the pleura; head dark gray; antennae (female) 15-segmented, brownish black throughout; femora obscure yellow, gradually passing into brown at tips; tarsi dark brown; wings brownish yellow, the prearcular and costal fields clearer yellow; very restricted pale brown clouds over the anterior cord and along vein  $Cu$  in cell  $M$ ; vein  $Sc_1$  ending a short distance before vein  $R_2$ ,  $Sc_2$  opposite or beyond the fork of  $R_{2+3+4}$ ; abdomen dark brown.

*Female*.—Length, about 7.5 mm.; wing, 9.3 mm.

Rostrum and palpi dark brown. Antennae brownish black, 15-segmented, there being two segments involved in the basal fusion-segment; outer segments long-oval, subequal in length to the verticils; terminal segment about two-thirds as long as the penultimate. Head uniform dark gray.

Pronotum obscure testaceous yellow. Mesonotum almost uniformly brownish gray, the praescutum clearer gray on sides, more darkened medially in front; posterior portions of scutal lobes more yellowed. Pleura brownish gray. Halteres yellow, knob weakly darkened. Legs with the coxae and trochanters yellow; femora obscure yellow basally, gradually passing into brown at the tips; tibiae brownish yellow, the tips gradually more infuscated; tarsi dark brown. Wings

brownish yellow, the prearcular and costal fields clearer yellow; a very ill-defined pale brown pattern, best evidenced as a small cloud over the anterior cord and a seam along vein *Cu* in cells *M* and *M*<sub>4</sub>; veins obscure yellow, a trifle darker in the clouded fields. Venation: *Sc*<sub>1</sub> ending only a short distance before *R*<sub>2</sub>, *Sc*<sub>2</sub> opposite or beyond the fork of *R*<sub>2+3+4</sub>; *Rs* gently arcuated; cell 1st *M*<sub>2</sub> long, exceeding vein *R*<sub>2+3+4</sub> in length; petiole of cell *M*<sub>1</sub> slightly longer than *m*; *m-cu* about one-third to two-fifths its length beyond the fork of *M*.

Abdomen dark brown, sparsely pruinose; ovipositor with the very powerful valves yellowish horn-color.

*Habitat*: Japan (Honshiu). *Holotype*, ♀, Gora, Hakone District, November 11, 1931 (Sawada).

*Cladura hakonensis* is entirely distinct from the other Japanese species, differing most evidently in the brownish gray coloration of the body, brownish black antennae, gradually darkened femoral tips, and the sparsely patterned wings. The only other species in the fauna having any wing pattern is the otherwise very different *C. machidella* Alexander.

#### *Cladura monacantha* n. sp.

General coloration yellow, unpatterned; femora with tips narrowly but conspicuously dark brown; wings unpatterned; male hypopygium with the tergite terminating in two small subcircular lobes; basistyle without lobes; dististyle single, stout, terminal in position; gonapophyses appearing as flattened blades, each bearing a single strong lateral tooth before the apex.

*Male*.—Length, about 6.5 mm.; wing, 8.5 mm.

Rostrum obscure yellow; palpi dark brown. Antennae with the scape blackened; pedicel more or less darkened; flagellum yellow; flagellar segments subcylindrical, with long conspicuous verticils; basal two flagellar segments fused but not compacted, the position of the suture indicated by a constriction. Head light yellowish brown, weakly pruinose, particularly on the anterior vertex and orbits; anterior vertex about three times the diameter of the scape.

Thorax uniformly yellow, the mesonotum slightly more fulvous. Halteres elongate, yellow. Legs with the coxae and trochanters light yellow; femora yellow, the tips very narrowly but conspicuously dark brown, the amount subequal on all legs; tibiae yellow, the tips even more narrowly darkened; tarsi dark brown. Wings whitish or very pale yellowish subhyaline, the prearcular field light yellow; veins brown. Venation: *Sc*<sub>1</sub> ending about opposite one-third the length of *R*<sub>2+3</sub>; *R*<sub>2+3+4</sub> about one-fourth longer than *R*<sub>1+2</sub>; petiole of cell *M*<sub>1</sub> a little longer than *m*; *m-cu* close to the fork of *M*.

Abdominal tergites weakly infuscated, somewhat paler laterally; basal sternites obscure yellow, the posterior margins narrowly more darkened; subterminal segments not conspicuously dark brown, as is common in various species of the genus; hypopygium brownish yellow. Male hypopygium with the central region of tergite slightly produced, the median portion still farther extended into two subcircular or suboval lobes. Basistyle elongate, without lobes. Dististyle terminal in position, simple, relatively stout, the blunt apex more or less lobed and



pendant. Gonapophyses longer than the aedeagus, appearing as relatively broad yellow blades, each broadest beyond midlength, narrowed to the subacute tip; lateral margin near apex produced into a single strong toothlike point; outer end of style at and near the tooth bearing several delicate setoid points, these continued basad along the mesal portion of the blade (in slide mounts) for about one-third the length; margins of the blade not produced into these hairlike extensions (as in the subspecies *fimbriata*).

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Tottori Prefecture, without further data (Sawada).

This fly, with its subspecies described below, is most nearly allied to *Cladura autumnata* Alexander, differing very evidently in the structure of the male hypopygium, as defined above.

*Cladura monacantha fimbriata* n. subsp.

Characters essentially as in the typical form, differing chiefly in minor hypopygial characters. Gonapophyses even narrower, the apex more acute, the lateral spine large and conspicuous; in addition to the microscopic setoid extensions near the apex and along the mesal portion of the blade, the outer margin at near midlength even more conspicuously produced into spines and setoid points.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Gora, Hakone District, November 11, 1931 (Sawada).

Genus *Erioptera* Meigen

*Erioptera (Psiloconopa) laudatrix* n. sp.

Size small (wing, male, under 4 mm.); general coloration brownish gray, variegated with obscure yellow; antennae short, outer flagellar segments subglobular; femora yellow, the tips broadly blackened; wings with a weak brownish tinge, very restrictedly patterned with darker brown; cell 1st  $M_2$  closed, small; male hypopygium with two blackened dististyles, subterminal in position, the glabrous outer style bispinous at tip, the inner style terminating in a single point.

*Male*.—Length, about 3.5 mm.; wing, 3.9 mm.

Rostrum obscure yellow; palpi brown. Antennae pale brown, pedicel a trifle darker; flagellar segments very short-oval to subglobular, the verticils exceeding the segments. Head brownish gray, the front and narrow posterior orbits clearer gray.

Pronotum obscure yellow. Mesonotal praescutum chiefly covered by three dark brownish gray stripes that are confluent or virtually so; cephalic border of median stripe more intensely darkened; humeral region broadly yellow; scutal lobes extensively brownish gray, the median area restrictedly obscure yellow; scutellum light yellow, with a narrow pale brown central vitta, parascutella darker; postnotum reddish brown, the posterior third darker. Pleura obscure brownish yellow, restrictedly patterned with dark brownish gray, most conspicuously so on the ventral sternopleurite and meron, narrower across the suture between the anepisternum and sternopleurite. Halteres with knob yellow, the stem a trifle darker. Legs with the coxae and trochanters reddish yellow, the fore coxae darker; femora yellow, the tips

broadly and conspicuously blackened; tibiae and proximal two or three tarsal segments obscure yellow, their tips narrowly infuscated; outer tarsal segments brownish black. Wings with a weak brownish tinge, the prearcular and costal fields more yellowed; a very restricted darker brown pattern, most evident as seams over  $Sc_2$ , tip of  $Sc_1$  and  $R_3$ , tip of  $R_{1+2}$  and along the cord; origin of  $Rs$  and outer end of cell 1st  $M_2$  scarcely darkened; veins brown, darker in the patterned areas, more yellowed in the flavous portions. Venation:  $Sc_1$  ending beyond  $R_3$ ,  $Sc_2$  about opposite one-fourth the length of  $Rs$ ;  $R_{2+3+4}$  subequal to the basal section of  $Rs$ , slightly elevated; veins  $R_3$  and  $R_4$  slightly divergent; cell 1st  $M_2$  closed, small,  $M_{3+4}$  about three-fifths as long as  $M_4$  alone;  $m-cu$  a short distance before the fork of  $M$ ; vein  $Cu_1$  sinuous on its distal half; vein 2nd  $A$  sinuous on the distal sixth.

Abdominal tergites pale brown, the caudal borders narrowly testaceous yellow, somewhat more extensively so on the outer angles; sternites obscure brownish yellow, the posterior borders very narrowly paler yellow; hypopygium chiefly pale, the proximal ends of the basistyles infuscated, the dististyles blackened. Male hypopygium with apex of basistyle produced beyond the point of insertion of the dististyles as a conical lobe extending to beyond midlength of the outer dististyle, tipped with long yellow setae. Both dististyles subequal in size, the outer style glabrous, a little dilated at base, its outer half generally parallel-sided, terminating in two acute spines that are separated by a shallow U-shaped notch; inner style roughly parallel-sided, at apex narrowed into a single spinous point, the surface with nearly 20 pale setigerous punctures, well-scattered over the surface. Lateral gonapophyses very small, appearing as darkened blades, the outer margin irregularly notched or crenate.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Gifu, June 19, 1932, at light (Kariya).

*Erioptera (Psiloconopa) laudatrix* is entirely different from the other species of the subgenus now known from Eastern Asia, being more like certain European species, including *E. (P.) grata* (Loew) and *E. (P.) pusilla* (Schiner). It differs from all known species in the structure of the male hypopygium. Superficially the fly somewhat resembles *E. (P.) machidai* Alexander but the actual relationship is not close. It should be noted that it is now considered that *Ilisia* Rondani is synonymous with the earlier *Psiloconopa* Zetterstedt.

#### *Erioptera (Empeda) brumalis* n. sp.

Size large (wing, male, 6 mm.); general coloration dark plumbeous gray; legs brownish black to black, without scales; wings grayish subhyaline, with a broad, conspicuous, brown seam from the stigma across the wing at the cord;  $Sc_1$  long,  $Sc_2$  ending about opposite six-sevenths the length of the long  $Rs$ ;  $Sc_1$  long, exceeding twice the length of  $r-m$ ; cell  $M_2$  open by the atrophy of  $m$ ; Anal veins divergent; male hypopygium with the inner dististyle blackened, the two arms very unequal, the shorter one greatly expanded into a flattened blade.

*Male*.—Length, about 5.5 mm.; wing, 6 mm.

*Female*.—Length, about 6–7 mm.; wing, 6.3–8 mm.

Rostrum and palpi black. Antennae black; scape enlarged; flagellar segments long-cylindrical, very slender, with very long verticils, longest on the more proximal segments. Head dark gray.

Thorax dark plumbeous gray, the praescutum with three more brownish stripes; dorsopleural membrane infuscated. Halteres yellow, a trifle more infuscated in male. Legs with the coxae dark plumbeous gray; trochanters brown; remainder of legs brownish black to black; vestiture of legs including large and smaller setae but no scales. Wings grayish subhyaline, restrictedly but conspicuously patterned with brown, including the stigma and a broad seam across the wing at the cord, the stigma more intense; prearcular field, including the veins, a trifle more yellowed; remaining veins brown. Venation:  $Sc$  long,  $Sc_1$  ending about opposite six-sevenths the length of the long  $Rs$ ,  $Sc_2$  some distance from its tip so  $Sc_1$  is unusually long, exceeding twice the length of  $r-m$ ; veins  $R_3$  and  $R_4$  weakly divergent, the former only about one-half to three-fifths as long as the latter; cell  $M_2$  open by the atrophy of  $m$ ;  $m-cu$  just before the fork of  $M$ ; Anal veins divergent, vein 2nd  $A$  beyond its base straight.

Abdomen dark brown, more or less gray pruinose; hypopygium brownish black; ovipositor with shield dark brown, valves horn-yellow. Male hypopygium of the general type of *fuscocincta* yet quite distinct, especially the inner dististyle. Both dististyles terminal in position, the outer one slender; inner style entirely blackened, the two arms very unequal, the shorter one greatly expanded into a blade, the second arm narrow, approximately as wide as the outer dististyle, its tip narrowly obtuse.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Gifu, March 13, 1932 (Kariya). *Allotopotype*, ♀, December 19, 1933 (Kariya). *Paratopotypes*, 1 ♀, January 17, 1934 (Kariya), 1 ♀ with the allotype.

*Erioptera (Empeda) brumalis* is entirely distinct from the other Eastern Asiatic species of the subgenus, differing particularly in the large size, patterned wings and structure of the male hypopygium. The most similar species is the western Chinese *E. (E.) fuscocincta* Alexander, which differs most evidently in the structure of the male hypopygium, particularly the inner dististyle.

#### Genus *Ormosia* Rondani

##### *Ormosia (Ormosia) subalpina* n. sp.

Allied to *nantaisana*; general coloration gray, the praescutum with a median brown stripe; antennae black throughout; legs dark brown, the femoral bases broadly yellow; wings with cell 1st  $M_2$  closed, vein 2nd  $A$  sinuous; male hypopygium with the outer dististyle very short and compact, the width across the head nearly equal to the length, the stem thus very stout; inner dististyle dark-colored, broad, almost as long as the basistyle; lateral gonapophyses greatly expanded at tips into flattened yellow blades.

*Male*.—Length, about 5.5 mm.; wing, 6 mm.; antenna, about 1.6 mm.

*Female*.—Length, about 7 mm.; wing, 7.5 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval, on the more proximal ones with the lower face a trifle

protuberant; longest verticils subequal to or shorter than the segments. Head gray.

Thorax almost uniformly gray, the pleura somewhat lighter; praescutum with the median stripe brown, the laterals scarcely defined; pseudosutural foveae black; dorsopleural membrane darkened. Halteres with the stem whitened, knob light yellow. Legs with the coxae plumbeous gray; trochanters brownish yellow; remainder of legs dark brown, with the femoral bases broadly yellow. Wings with the ground color yellow, the prearcular and costal fields clearer yellow; stigma brown; a restricted brown pattern along the veins, including the cord and along vein *Cu* in cells *M* and *M*<sub>4</sub>; outer end of cell 1st *M*<sub>2</sub> and some of the veins beyond the cord less evidently seamed; veins light brown, darker in the patterned areas, yellow in the flavous fields. Venation: *R*<sub>2</sub> immediately beyond the fork of *R*<sub>2+3+4</sub>, *R*<sub>2+3</sub> being very short to virtually lacking; vein *R*<sub>3</sub> gently upcurved at tip; cell 1st *M*<sub>2</sub> closed, *m-cu* from one-third to one-fourth its own length beyond the fork of *M*; vein 2nd *A* sinuous, the distal third of the cell narrowed, particularly in the male.

Abdomen of male brown, the hypopygium still darker; in the female, abdomen uniformly dark brown; cerci long and slender, gently upcurved. Male hypopygium having the general structure of *nantaisana* but with all characters even more accentuated, particularly the dististyles. Outer dististyles very short and compact, subtriangular in outline, the width across the head nearly equal to the length, the stem correspondingly stout. Inner dististyle much larger than in *nantaisana*, being fully as long as the basistyle, dark-colored, appearing more or less mitten-shaped, fully twice as wide as in *nantaisana*. Lateral gonapophyses much larger than in *nantaisana*, their tips greatly expanded into flattened yellow blades.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Mt. Kurobegoro, Toyama (Japanese Alps), altitude 2,400 meters, August 8, 1931 (K. Imanishi); No. 5016, through Tokunaga, No. 145. *Allotopotype*, ♀, with the type; No. 5017.

The present fly is related to *Ormosia* (*Ormosia*) *nantaisana* Alexander, from which it differs very evidently in the structure of the male hypopygium, as detailed above. I had earlier determined this material as being *nantaisana* but the receipt of more material of this latter species has demonstrated the specific distinctness of the two flies.

#### *Ormosia* (*Ormosia*) *ontakeana* n. sp.

Size large (wing, female, 7.5 mm.); general coloration of head and thorax gray; antennae black throughout; halteres short, light golden yellow; legs uniformly brownish black; wings broad, ground color grayish, the large stigma dark brown, conspicuous; *R*<sub>2+3+4</sub> long and nearly straight, about twice the oblique *r-m*; cell 1st *M*<sub>2</sub> closed, subequal in length to vein *M*<sub>4</sub>; *m-cu* from one-third to one-half its length beyond the fork of *M*; vein 2nd *A* sinuous.

*Female*.—Length, about 7 mm.; wing, 7.5 mm.

Rostrum dark brown; palpi brownish black. Antennae black throughout; basal flagellar segments long-oval, the outer ones passing through subcylindrical to virtually cylindrical; terminal three seg-

ments subequal in length; verticils slightly exceeding the segments. Head gray.

Pronotum brown, gray on the sides; scutellum and pretergites clear light yellow. Mesonotum and pleura almost uniformly gray over a brown ground; praescutal pattern not visible in the unique type. Halteres short, knobs large, entirely light golden yellow. Legs with the coxae brownish gray; trochanters yellow; remainder of legs uniformly brownish black. Wings broad, the ground color grayish, the prearcular and costal fields more brownish yellow; stigma dark brown, conspicuous; a scarcely evident darkening along the cord, best-evidenced by a deepening in color of the veins; veins brown, those in the brighter fields and toward the wing base somewhat paler. Macrotrichia delicate but distributed over the entire wing. Venation:  $Sc_1$  ending just beyond the oblique  $R_2$ ,  $Sc_2$  about opposite midlength of  $R_3$ ;  $R_{2+3+4}$  long and nearly straight, about twice the oblique  $r-m$ ; vein  $R_3$  only slightly upcurved at its outer end; cell 1st  $M_2$  closed, subequal in length to vein  $M_4$  beyond it;  $m-cu$  about one-third to one-half its length beyond the fork of  $M$ ; vein 2nd  $A$  sinuous.

Abdomen almost uniformly dark brown; ovipositor with the cerci horn-yellow, more darkened basally.

*Habitat*: Japan (Honshiu). *Holotype*, ♀, Ontake, Hida, southern Alps, altitude 5,850 ft., July 6-10, 1934 (H. Ise); through Kariya.

Although only the female sex is available, there is no question of the distinctness of the present fly. From the other species having cell 1st  $M_2$  closed and with vein 2nd  $A$  strongly sinuous, including *Ormosia* (*Ormosia*) *nantaisana* Alexander and *O.* (*O.*) *subalpina* sp. n., it is readily told by the almost unpatterned wings, uniformly blackened legs, and the details of venation, including the course of  $R_2$  and  $r-m$ , and the lengths of vein  $R_{2+3+4}$  and cell 1st  $M_2$ .

#### *Ormosia* (*Ormosia*) *kamikochiae* n. sp.

Belongs to the *similis* group; general coloration of the mesonotum light brown, the posterior sclerites and the pleura more pruinose; antennae short; legs brown, the femoral bases broadly yellow; wings with cell  $M_2$  open by the atrophy of the basal section of  $M_3$ ; vein 2nd  $A$  sinuous on the distal third; male hypopygium with the gonapophyses unequally bispinuous; aedeagus a slender black rod, its tip subacute.

*Male*.—Length, about 4.5 mm.; wing, 4.8 mm.; antenna, about 1 mm.

*Female*.—Length, about 5 mm.; wing, 5 mm.

Rostrum brown; palpi black. Antennae short in both sexes; scape and pedicel brown, flagellum somewhat darker; flagellar segments long-oval to subcylindrical; longest verticils unilaterally arranged and much longer than the segments. Head dark brownish gray.

Pronotum and mesonotum almost uniformly light brown, the posterior sclerites and the pleura more pruinose to produce a plumbeous appearance. Halteres pale yellow. Legs with the coxae obscure yellow, the fore pair darker, sparsely pruinose; trochanters yellow; femora obscure yellow basally, with about the outer half dark brown; remainder of legs light brown, the terminal tarsal segments darker. Wings with a weak brownish tinge, the prearcular and costal fields somewhat more

yellowish brown; stigma darker brown than the ground; veins light brown. Macrotrichia of cells abundant but delicate. Venation:  $Sc_1$  ending opposite  $R_2$ ; cell  $M_2$  open by the atrophy of the basal section of  $M_3$ ;  $m-cu$  close to the fork of  $M$ ; vein 2nd  $A$  sinuous on its distal third.

Abdomen, including the hypopygium, dark brown. Male hypopygium with the ninth tergite conspicuous, narrow but very deeply split medially. Outer dististyle small, densely covered with short appressed setae, arranged in parallel rows as in the group. Inner dististyle larger, dilated at base, the apex narrowed, the lower surface filled with pale membrane. Each gonapophysis appearing as a conspicuous blackened bispinous structure, the spines slender and very unequal, the longer one strongly curved at midlength, the shorter and more basal spine about one-half as long, directed caudad. Aedeagus appearing as a further slender straight blackened rod, the tip subacute or very narrowly obtuse.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Kamikochi, Shinano, altitude 5,000 ft., August 18-21, 1934 (Kariya). *Allotopotype*, ♀, pinned with the type.

The present fly is quite distinct from the other regional members of the group, being most similar to *Ormosia* (*Ormosia*) *machidai* Alexander and *O. (O.) seclusa* Alexander, but differing from these and all others in the structure of the male hypopygium.

#### *Ormosia* (*Ormosia*) *dicax* n. sp.

Belongs to the *similis* group; size medium (wing, male, 5 mm. or a trifle more); general coloration of thorax light gray, the praescutum unpatterned; halteres light yellow; femora yellow, the tips infuscated; wings whitish subhyaline, the prearcular and costal fields light yellow; a restricted brown pattern, the largest areas being the stigma and a conspicuous seam along vein  $Cu$ ; cell  $M_2$  open by the atrophy of the outer deflection of  $M_3$ ; Anal veins divergent; male hypopygium with the inner dististyle stout, including the obtuse tip; each gonapophysis appearing as a simple elongate sinuous yellow blade, nearly as long as the basistyle, narrowed gradually to the acute tip.

*Male*.—Length, about 4.2-4.5 mm.; wing, 5-5.5 mm.; antenna about 0.9 mm.

*Female*.—Length, about 5 mm.; wing, 5.2 mm.

Rostrum brownish yellow; palpi brown. Antennae short, as shown by the measurements; scape and pedicel yellow, flagellum brown; flagellar segments oval, the longest verticils slightly exceeding the segments. Head gray.

Pronotum pale brown or brownish yellow, sparsely pruinose. Mesonotum clear gray, the tuberculate pits and pseudosutural foveae black; praescutal stripes not indicated. Pleura gray, the dorsopleural region and pretergites yellow. Halteres light yellow, especially the knobs. Legs with the coxae yellow, the fore pair a little darker; trochanters yellow; femora yellow or brownish yellow, the tips infuscated; tibiae yellow, the tips more narrowly darkened; tarsi passing into black. Wings whitish subhyaline, prearcular and costal fields yellow; a restricted brown pattern, including the stigma, a broad seam along vein  $Cu$  and less evident cloudings along cord and as barely indicated mar-

ginal darkening at ends of the veins; veins light brown, darker in the clouded areas, yellow in the flavous portions. Venation:  $R_2$  at or very close to the fork of  $R_{2+3+4}$ ; tips of veins  $R_3$  and  $R_4$ , especially the former, slightly upcurved; cell  $M_2$  open by the atrophy of basal section of  $M_3$ ;  $m$  at its junction with outer section of  $M_3$  square and, in cases, more or less spurred;  $m-cu$  at fork of  $M$ ; Anal veins gradually divergent.

Abdomen brownish black, the basal sternites more reddened; hypopygium varying from obscure yellow to dark brown. Male hypopygium with the tergite broad, the sides and the caudal margin gently emarginate, the outer third pale. Inner dististyle relatively stout, including its obtuse apex. Gonapophyses appearing as simple elongate sinuous yellow blades that narrow very gradually to the acute tips, the total length of either apophysis nearly equal to the basistyle.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Hamasaka, Hyogo (Tottori), April 1, 1931 (Okada). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 3 ♂♂, March 25–April 1, 1931 (Okada).

*Ormosia* (*Ormosia*) *dicax* is entirely different from the most similar regional species, including *O. (O.) takeuchii* Alexander and *O. (O.) takahashii* Alexander, both of which have the male hypopygium, especially the gonapophyses, entirely different.

### Genus *Molophilus* Curtis

#### *Molophilus* (*Molophilus*) *efferox* n. sp.

Belongs to the *gracilis* group and subgroup; general coloration of body black; antennae short; halteres entirely pale yellow; femora black, the bases broadly obscure yellow; wings with a weak brownish tinge, the base brighter; male hypopygium with the ventral lobe of basistyle very small, the dorsal or lateral ones very powerfully developed into spines, one a long curved simple rod, the other bifid into two unequal spines; two dististyles, the longest at about two-thirds the length bent at nearly a right angle; shorter spine sinuously bent, the tip a long slender spine.

*Male*.—Length, about 4.5 mm.; wing, 4.7 mm.; antenna, about 0.9 mm.

Rostrum and palpi black. Antennae short; scape black, pedicel more piceous, flagellum brownish black; flagellar segments oval, the outer ones a little more elongate. Head brownish black.

Thorax almost uniformly blackened, the surface with a vague pruinosity to produce a weak plumbeous appearance. Halteres uniformly very pale yellow. Legs with the coxae brownish black; trochanters obscure brownish yellow; femora with about the proximal third or fourth obscure yellow, the remainder passing into brownish black; tibiae and basitarsi light yellowish brown, the outer tarsal segments more strongly infuscated. Wings with a weak brownish tinge, the prearcular and costal fields light yellow; veins and macrotrichia darker brown, the veins in the paler fields brownish yellow. Venation:  $R_2$  lying a short distance beyond the transverse level of  $r-m$ ; petiole of cell  $M_3$  nearly three times  $m-cu$ , the latter only a short distance beyond the fork of  $M$ ; vein 2nd  $A$  long, gently sinuous, ending about opposite midlength the petiole of cell  $M_3$ .

Abdomen, including hypopygium, black. Male hypopygium with the apical lobes of the basistyle much developed; ventral lobe unusually small, only about twice as long as its diameter at base; outer or lateral portion of style produced into two lobes that lie close together at base, one a long curved spine that is nearly as long as the longest dististyle, the other shorter but broader at base, split into two unequal acute spines, the shorter of which is more slender. Two dististyles, the longest strongly bent at about two-thirds its length into a long straight spine; lower style shorter, the proximal half broader, the distal portion sinuously bent, thence narrowed into a slender, very acute spine, the ventral margin with a few scattered spinous points. Aedeagus long and slender. Phallosomic plate relatively narrow, obtuse at tip, the surface with microscopic setulae.

*Habitat*: Japan (Honshiu). *Holotype*, ♂, Kamikochi, Shinano, altitude 5,000 ft., August 18-21, 1934 (Kariya).

While differing entirely in the black coloration, the present fly suggests *Molophilus* (*Molophilus*) *ferox* Alexander, likewise from the Japanese Alps, in the unusual development of spinuous points on both the basistyle and dististyles of the male hypopygium. The Korean *M. (M.) avidus* Alexander has a somewhat similar modification of the dorsal lobe of the basistyle but differs in all details of structure of both the basistyle and dististyles.

GENERAL CATALOGUE OF THE HEMIPTERA, FASCICLE V, POLYCTENIDAE, by ROBERT LESLIE USINGER. 18 pages, 1946. Published by Smith College, Northampton, Mass. Price 60 cents.

In this fascicle of the Catalogue of the Hemiptera Dr. Usinger treats the curious little ectoparasitic bugs whose hosts are bats. His prefatory statement that less than one hundred specimens have been accumulated in the insect collections of the world suggests that the catalogue will be of limited use. It should, however, be stimulating to insect collectors. The next bat that makes its home under the reviewer's back porch is likely to be a martyr to science, even though the host relationships and geographic distribution recorded by Dr. Usinger lay heavy odds against its providing any parasitic bugs.—A. W. L.



## BOOK NOTICE

FLEAS OF WESTERN NORTH AMERICA, by CLARENCE ANDRESEN HUBBARD.  
ix+533 pages. The Iowa State College Press, Ames, Iowa. 1947. Price  
\$6.00.

Since entomological books very rarely have enough popular appeal to find their way into leading magazines, the review of the *Fleas of Western North America* in *Time* during March, 1947, is a mark of almost unique distinction. The attention is well deserved, for the book is an impressive contribution to taxonomy and the forty pages of the first part, dealing with historical matters, economic importance and methods of collecting and preparing specimens, are exceedingly interesting whether one is a specialist on the order or not.

The area covered by the book is North America west of the 100th meridian where, according to the preface, 66 genera and over 230 species and subspecies of fleas occur, as compared with 33 genera and 55 species from the eastern part of the continent. The occasional outbreaks of bubonic plague in the west and the transmission of typhus and tularemia by fleas over much wider areas add to the importance of the volume beyond its purely taxonomic value.

The first chapter is a brief history of the study of western fleas with notes on the lives of such outstanding pioneers as N. Charles Rothschild and Karl Jordan as well as the American specialists. Their publications and interesting items of their work are also discussed. Chapter 2 covers the economic relations of fleas in the transmission of bubonic plague, typhus, and tularemia and as pests to man and domestic animals. The account contains information on the incidence of the diseases in North America, on their nature and effects, and on mortality and immunization. Chapter 3 on field and laboratory technique is a compact manual for the collector. Chapter 4, of two pages, is a description of the anatomy of the flea for taxonomic use, illustrated with one plate covering the anatomy and life history. This chapter completes part I.

Part II, Systematic Classification occupies pages 41 to 390, the greater part of the book. The author restricts bibliographic citations as was evidently necessary to keep the material within reasonable limits. His treatment includes excellent figures of anatomical details, brief descriptions, and comprehensive records of distribution and host relationships. His own extensive collecting has been responsible for many of the data. Biology, economic and medical importance and methods of control are also discussed.

Part III covers the hosts of Western rodent fleas and Lagomorpha fleas and their relation to plague, tularemia and murine typhus. The species of fleas recorded from each host species are listed and incidence of disease in these hosts is discussed. Practical notes on habits and methods of trapping are also included.

A bibliography of four pages, synonymic, alphabetic and author indices to species, and a general index conclude the book.

For the entomologist who can go into the field with only a net and cyanide bottles and means of caring for his specimens the book is a vivid exposition of the complexity of collecting parasitic insects. The student of fleas must be primarily a collector of mammals and birds with expert knowledge of their classification and habits if he is to realize his primary goal of securing adequate numbers of their parasites. Dr. Hubbard's discussion of the hosts reveals an amazing amount of detailed knowledge, much of it interesting to any reader whose collecting has brought him incidentally into contact with the abundant small mammals of the western mountains. For his many thousands of miles of travel on collecting expeditions and for his knowledge and skill one can only feel admiration and a measure of envy as he reads between the lines of purely factual discussions.

Our congratulations to Dr. Hubbard on a superb entomological contribution.

—A. W. L.

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NOTES ON SOME REMARKABLE AUSTRALASIAN  
WALKINGSTICKS, INCLUDING A SYNOPSIS OF  
THE GENUS *EXTATOSOMA*  
(Orthoptera: Phasmatidae)

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This paper presents notes and photographs of species belonging to four of the more striking genera of Australasian walkingsticks, and it is hoped that some of the material contained may be of interest to general entomologists and teachers.

A few records regarding the largest known Phasmatidae may be presented here. The largest, which likewise have the greatest body length of living insects, belong to the genus *Pharnacia* and inhabit Borneo. Redtenbacher (1908) cites a female of *P. serratipes* (Gray) measuring 330 mm. (13 inches); Kirby (1896) recorded one of the same species as 12½ inches long, but later (1904) referred his specimen to *P. maxima* (Bates). A female from Borneo in the United States National Museum, probably of one of the above species, is 11 inches (279.4 mm.) long. Gunther (1943, p. 155) recorded a Bornean female of *Pharnacia sagitta* Redt. 280 mm. long. The taxonomy of the species referred to *Pharnacia* is in a confused state, and species now assigned to the genus *Phobaeticus* are also involved. Chopard (1938, p. 20; 1945, p. 31) refers to species of *Phobaeticus* 300 mm. or more in length. Karny (1914, p. 9) has discussed several walkingsticks which attain a length of approximately one foot. So far as known, the smallest walkingsticks belong to the genus *Timema*, a male of *T. californicum* Sc. having been recorded by Hebard (1920a) as 12.5 mm. long.

The largest walkingstick living in the United States is *Megaphasma denticrus* (Stal), females of which reach 150 mm. in body length (see Hebard, 1943, p. 309). A female of that length from Musson, La., is in the National Museum. At the other extreme in the size of adult Orthoptera, Hebard (1920, p. 109) records a male of the cricket

*Myrmecophila nebrascensis* Lugger from Arizona as 1.3 mm. long, but the specimen may have been imperfect as he says (p. 94) that a depauperate specimen of *nebrascensis* 1.47 mm. long is the smallest adult orthopteron known to him. Smaller species occur in several orders of insects, particularly in the Hymenoptera, Coleoptera, Diptera, Homoptera, and Corrodentia.

A specimen (figs. 1, 2) of *Extatosoma popa* Stal, collected by a member of the armed forces in New Guinea, supplied the original incentive for gathering these notes, and this fact suggests that entomologically minded service men may find represented here certain of the forms encountered during overseas travels.<sup>1</sup>

Of the four genera treated, two (*Extatosoma*, *Dryococelus*) are given complete systematic coverage; but only general features or those of biological interest of the other two (*Cotylosoma*, *Eurycantha*) are discussed. *Cotylosoma* is one of the phasmatid<sup>2</sup> genera for many years erroneously supposed to be aquatic. The four genera do not of themselves constitute a natural group, though all belong to the subfamily Cladoxerinae (Phibalosomini of Redtenbacher), and *Dryococelus* and *Eurycantha* are closely related members of the Group Eurycanthae. *Dryococelus* is a new genus based on *Karabidion australe* Mont. The genus *Karabidion* has been found to be a synonym of *Eurycantha*, and the nomenclatorial matters involved are herein discussed under *Dryococelus*.

### Genus *Extatosoma* Gray

*Extatosoma* Gray, 1833, Ent. Australia, pt. 1, Phasma, p. 23. Genotype, *Phasma tiaratum* W. S. MacLeay, 1826. (Selected by Kirby, 1904.)

*Extatosoma* Gray, 1835, Synopsis Phasmodae, p. 29. (Emendation for *Extatosoma*).

*Generic description* (adapted with modifications from Westwood, 1859, p. 170)—Body large and spinose, the male winged, female brachypterous; certain middle segments of the abdomen of both sexes with lateral tergal lobes, these much more expanded in female than in male. Head prognathous, dorsal apex conical and spinose; ocelli distinct in male, lacking or evanescent in female; antennae simple, moderately pubescent. Mesothorax dilated posteriorly, less than twice prothoracic length. Tegmina of both sexes abbreviate, those of female somewhat broader than those of male; wings of male extending about to or beyond apex of abdomen, of female abbreviate, sometimes

<sup>1</sup>William J. Baerg, of the University of Arkansas, kindly made a specimen of *Extatosoma popa* available for study, and specimens located at the Academy of Natural Sciences of Philadelphia and the Museum of Comparative Zoology were studied through the kindness of James A. G. Rehn and John W. H. Rehn, and Joseph Bequaert, respectively, to whom I am particularly indebted for their cooperation. All photographs were made by Marcel L. F. Foubert, of the U. S. Department of Agriculture, whose skilled and careful work is demonstrated on the accompanying plates. The Linnean Society of New South Wales has kindly given permission to reproduce a photograph of *Extatosoma elongatum* Froggatt. Plates IV and VII were made from specimens belonging to the Academy of Natural Sciences of Philadelphia.

<sup>2</sup>The family name of the walkingsticks is considered to be Phasmatidae, derived from the stem of *Phasma*, as explained by Roberts (1944, p. 16), rather than the better known name Phasmidae. Descriptions of body spination utilize some of the names for standard body spines proposed as a system of acanthotaxy by Rehn and Rehn (1939).

shriveled and rudimentary. Legs moderately long to short; femora and tibiae spinose, trigonate, broadly dilated, more markedly so in female; ventral surface of middle and hind tibiae without apical triangular area, bearing apical hooked spine; basitarsus somewhat shorter than remaining tarsal segments. Ovipositor sheath of female boat-shaped and extending posteriorly beyond apex of abdomen; ovipositor valves long, filamentous, apically curved.

There is little likelihood of confusing the very distinctive females with those of any other genus. Males superficially suggest several genera, but may be assigned to *Extatosoma* by habitus and the combination of the foregoing characters. The relative scarcity of males may have prevented any large amount of misplacement of this sex in the past. Brullé (1836, p. 113) treated *Ectatosoma* as a synonym of *Tropidoderus* Gray 1835, a valid and very distinctive Australian genus.

The name *Extatosoma* is from two Greek words meaning, "capable of extension" and "body."

*Distribution of genus*—New Guinea, Australia, Lord Howe Island.

Since the male of only one species (*tiaratum*) is known, the following key includes only females.

#### KEY TO THE SPECIES OF EXTATOSOMA (FEMALES)

1. Fifth, sixth and seventh terga bearing lateral expansions which overlap when seen in dorsal view (fig. 1)..... 2
- Fifth, sixth and seventh terga bearing much smaller, non-overlapping expansions (fig. 4)..... *elongatum*
2. A conspicuous V-shaped pale mark on mesonotum (fig. 1); metanotum and first tergum each with a pair of erect, well-developed lamellae (fig. 2); dorsal lamellae of fifth and sixth terga each occupying about one-third the length of segment, the base of each scarcely wider than apex and not extending in front of middle of segment; a compound lamellate spine on mesonotum between bases of tegmina..... *popa*
- No V-shaped pale mark on mesonotum; median lamellae of metanotum and first tergum absent or weakly developed, spines occurring there either separate or weakly confluent basally; dorsal lamellae of fifth and sixth terga extending in front of middle of segment, the base of each lamella wider than the apex (fig. 3); spines at base of mesonotum individual..... *tiaratum*

Westwood (1874, p. 174, pl. 32, figs. 2, 2a) described *Extatosoma bufonium* from Australia with no specific locality mentioned. The material, deposited in the Hope Collection at Oxford, consists of a single specimen 1½ inches long. Rainbow (1897), Kirby (1904, p. 381) and Tepper (1903, p. 283) have merely cited *bufonium*, and Redtenbacher (1908, p. 381) and Froggatt (1922) have observed that the type specimen is immature and of uncertain position. A female nymph of *tiaratum* from New South Wales, which is 1½ inches long, differs noticeably from Westwood's clearly drawn figures of *bufonium*. The specimen figured likewise differs from male nymphs of *tiaratum* examined which range from 37 mm. to 65 mm. in length. The figures are much more suggestive of *elongatum* than of *tiaratum*, but may not even represent this genus and so for the present *bufonium* remains unplaced. Study of a series of *elongatum* nymphs, should they become available, might add information, perhaps showing the latter name to be a synonym of *bufonium*.

*Extatosoma tiaratum* (W. S. MacLeay)

Figures 3, 5

*Phasma tiaratum* W. S. MacLeay, 1826,<sup>3</sup> Insects in: King's Narr. Surv. Coasts Australia, 2, p. 455, Tab. B, figs. 3, 4.

*Extatosoma Hopei* Gray, 1833, Ent. Australia, pt. 1, Phasma, p. 25. (As *E. Hopii*, *ibid.*, p. 23.)

*Descriptive notes* (female)—Ocelli indicated by slight swellings, covered by integument; head conspicuously spined, about four pairs of spines of occipital medial series and same number of supraorbitals may or may not be present; a small, basally lamellate compound spine at each side of occipital crest; two pairs of median coronals posterior of crest; antennae simple, moderately long.

Pronotum elongate-rectangular, slightly rounded posteriorly; spination variable in size and number, anterior laterals present, also about three pairs anterior mesals, three pairs interposteriors and a pair of posterior medials. Mesonotum with well-developed pair of premedians, 4-6 laterals, and a pair of simple interposterior mesonotals between tegminal bases. Tegmina and wings essentially as in *elongatum* (fig. 4), wings sometimes not exceeding apices of tegmina. Simple median spines of metanotum and first tergum present, sometimes weakly confluent to make small lamellae. Abdomen usually robust, somewhat depressed; lateral expansions of fifth, sixth and seventh terga overlapping as in *popa* (fig. 1), development averaging smaller than in that species; spination following same pattern as in *popa* and *elongatum*: dorsal lamellae of fifth and sixth terga (fig. 3) recumbent or semierect. Legs with expansions much as in *popa*, development averaging smaller; tibial expansions occasionally bilobed, those of front tibiae often strongly so.

Coloration: General color in life dark green with grayish mottled areas, especially laterally. Preserved specimens varying shades of brown, tegmina and wings usually a dull green. Froggatt (1922) reported two bright yellow females, considered by him a remarkable variation.

Measurements: Body length said by Froggatt (1905) to reach 5 inches. Representative specimen (length): Body (head to apex of ultimate tergum), 110 mm.; front femur, 26 mm.; hind femur, 30 mm.; hind tibia, 30 mm.; pronotum, 9.5 mm.; mesonotum, 15 mm.; tegmen, 16 mm.; wing, 18 mm.; ovipositor sheath, 22 mm.

*Male* fig. 5—Three ocelli raised in a conspicuous cluster; head with strong trigonal spine each side of occipital crest, one pair of rudimentary median coronals posterior of crest, otherwise unspined; antennae simple, the segments weakly clavate. Pronotum with only

<sup>3</sup>The title page of this work bears the date 1827, which has usually been credited to it, but Austen (Ann. and Mag. Nat. Hist., (8), vol. 13, pp. 265-266, 1914) states that he was informed by C. Davies Sherborn that the work was actually issued April 18, 1826.

## EXPLANATION OF PLATE I

FIGURE 1. *Extatosoma popa* Stal, female, dorsal view. Buna, N. E. New Guinea, December, 1943. Body length, 125 mm.



1.

rudimentary spines; wider than anterior margin of mesonotum. Mesonotum with pair of erect, elongate, premedian mesonotals one-third mesonotal length from anterior margin; otherwise unspined. Terga unspined; lateral expansions well developed on tergum 6, weak on 5 and 7. Ultimate tergum apically truncate, strongly convex, in lateral view seen to possess a strong lateral carina on each lateral half extending ventroposteriorly to posterior margin. Metasternum and abdominal sterna 2 and 3 strongly spined. Three segments of poculum<sup>4</sup> increasing regularly in size posteriorly, the ultimate segment in lateral view triangularly produced ventroposteriorly. Each cercus swollen in apical half, tapering from there to the apex and weakly flattened. Legs with lateral expansions developed to a lesser degree than in female. Wings as illustrated.

Coloration: According to Gray (1833,) the tegmina and costal margins of wings are green, the anal field of wing is blackish, with transverse irregular white bands; the abdomen is brownish green; the legs green with blackish, narrow, transverse bands. The general color of the dried alcoholic males examined is light brown.

Measurements (length): Body, 83 mm.; front femur, 22 mm.; hind femur, 22 mm.; hind tibia, 21 mm.; pronotum, 6 mm.; mesonotum, 8 mm.; tegmen, 18.5 mm.; wing, 73 mm.

*Nymph* (female)—Only specimen examined 48 mm. in length. Form very much like adult. Compound spines of occipital crest, premedian mesonotals, lateral expansions of fifth, sixth and seventh terga, paired median dorsal lamellae of fifth and sixth terga, and expansions of femora and tibiae strongly developed and essentially as in adult, paired median dorsal lamellae of metanotum and terga 1-4 more conspicuously developed than in adult, that of first tergum largest though only two-thirds the size of that of fifth tergum. Color in life apparently green.

*Nymph* (male)—Four specimens ranging from 37 mm. to 65 mm. in body length examined. Form much as in adult. Occipital spines, those of mesonotum, and expansions of femora and tibiae well developed; well formed tegminal and wing pads.

The association of the male (upon which the names *Hopii* and *Hopei* were based) and female was first recognized by Burmeister (1838, p. 576), suggested by Serville (1839, p. 287), and followed by subsequent authors. This insect has been cited as occurring from New Guinea to Tasmania, but Froggatt (1922) says that it is not known south of New South Wales. New Guinea records may all date back to Haan (1842) who identified as *tiaratum* the species later described as *popa*, particularly as the Haan record is repeated in uncorrected form in Rainbow's 1897 catalogue. Redtenbacher (1908) and Gunther (1932, pp. 782, 790, 825) list *tiaratum* from Lord Howe Island, although

<sup>4</sup>See Rehn and Rehn, 1939, footnote, p. 412.

#### EXPLANATION OF PLATE II

FIGURE 2. *Extatosoma popa* Stal, female, lateral view. Same specimen as in figure 1.

FIGURE 3. *Extatosoma tiaratum* (W. S. MacLeay), female, lateral view of fourth, fifth and sixth terga. New South Wales.





it was not mentioned by Olliff (1889). It is fairly common in New South Wales and Queensland. The best accounts of *tiaratum* are by Froggatt (1905, 1907) and McKeown (1940, 1944). Both authors mention the rarity of males. It has been suggested that males, because of their ability to fly, remain in trees some height from the ground, while the flightless, heavily bodied females tend to remain low where they are easily collected. The food plants include various shrubs and trees, and the species has even been collected from orchard peach trees, but a critical study of its preferred host plants does not seem to have been made.

Froggatt found about 100 eggs in each of several females examined. The egg has been described and figured by Kaup (1871), the figure being reproduced by Chopard (1938, p. 175, fig. 151). I have removed an egg from the ovipositor of a female from New South Wales which agrees with Kaup's material. The egg is  $5\frac{1}{4}$  mm. long, oval, and slightly flattened. The chorion is much roughened and gray in color. There is an operculum bearing a convex, knoblike crown. Along one side is a raised, straplike, yellow thickening of distinctive shape.

The name *tiaratum* is taken from a Latin word meaning, "wearing a turban," in allusion to the spines at the crest of the occiput.

Material of *tiaratum* examined: ♀, near Babinda, Queensland, April, Schevill (M. C. Z.); ♀, Woodlford, Queensland, Harvard Australian Expedition, P. J. Darlington (M. C. Z.); ♀, Yungaburra, Queensland, 2,500 ft., April, P. J. Darlington (M. C. Z.); 3 ♀, 2 ♂, 4 ♂ nymphs, 1 ♀ nymph, New South Wales (8 A. N. S. P., 2 U. S. N. M.); ♀, "Australia," C. M. Hoy (U. S. N. M.).

### *Extatosoma popa* Stål

Figures 1, 2

*Extatosoma popa* Stål, 1875, Rec. Orth., p. 84.

*Phasma* (*Extatosoma*) *tiaratum* MacL., Haan, 1842,<sup>5</sup> Temminck, Verhandel., Orth., p. 110, pl. 10, fig. 2. (Misidentification in part.)

*Descriptive notes* (female).—Very much like *tiaratum*, differing in key characters, average greater body length, and greater size development of dorsal spines. Pronotum with posterior medial spines varying from single to compound. Tegmina and wings somewhat more rudimentary than in *tiaratum*. Well-developed, paired median lamellae on mesonotum, metanotum and first to sixth terga (lacking on tergum 4, fig. 2, due to breakage). Spination of fourth, fifth and sixth abdominal sterna reduced, all except laterals lacking or poorly developed (these strongly developed in *tiaratum*).

Coloration: Preserved material brown, the head paler than the abdomen, the most striking color feature being the illustrated V-shaped mesonotal pale mark. Apical half of flexor surface of hind tibia and first four segments of hind tarsus sometimes (specimen from Sattelberg) glossy shining black. Coloration in life unknown.

Measurements (specimen from Buna) (length): Body, 125 mm.; front femur, 25 mm.; hind femur, 25 mm.; hind tibia, 32 mm.; pronotum, 11 mm.; mesonotum, 16.5 mm.; tegmen, 11.5 mm.; wing, 7.5

<sup>5</sup>It appears that plate 10 was published in 1840, together with pages 1-44 and plates 1-9 of the section of insects of this general zoological work.

mm.; ovipositor sheath, 22 mm. Body length of Sattelberg specimen, 110 mm.

Knowledge of this unusual insect dates from Haan (1842) who published a colored, life-size, dorsal view illustration. The V-shaped mesonotal mark and other characteristic features are so clearly shown in his figure that there is no question regarding the identity of the species. Two small lateral views of hind and middle femora were also shown. He used the name *tiaratum* for his material, but indicated a portion of it (a) as being from the coast of the middle part of eastern New Guinea, the remainder (b) from Van-Diemen Land. The latter term has been applied in past years to Tasmania as well as to parts of Northern Australia, but since *Extatosoma* is not definitely known from Tasmania, Australia was probably the source of the material and true *tiaratum* may have been included. In any event, Stal (1875), recognizing the illustrated New Guinea form of the genus as distinct from the previously known Australian *tiaratum*, proposed the new name *popa* and mentioned the differentiating characters. (The Latin word "popa" means a type of Roman priest and is sometimes used in allusion to an enlarged stomach or paunch, the association in this case evidently referring to the greatly dilated fifth, sixth and seventh terga.) Redtenbacher (1908, p. 381) treated Haan's material of categories "a" and "b" as *popa* and *tiaratum*, respectively, and gave a formal description of *popa*. He gave the body length as 152 mm., which is scarcely more than the length to the tip of ovipositor sheath of the female here recorded belonging to the Academy of Natural Sciences of Philadelphia. Crampton (1916, pp. 15, 38, pl. 2, figs. 11, 14) illustrated the lateral expansions of the terga and compared them with lateral thoracic and abdominal expansions of various other insects. Franz (1930) published a life-size photograph of a female in lateral view, under the name *tiaratum*, and without a definite locality for the specimen illustrated.

Only a few specimens have been recorded, so that no clear definition of the geographical area occupied, other than eastern New Guinea, may be made. During the past 20 years Gunther has written numerous and extensive papers on the walkingsticks of New Guinea and the Bismarck Archipelago, based primarily on collections made by German scientists prior to the first World War. It is significant that very little material of *popa* has been reported by him, and he has mentioned (1932, p. 817) the sparse occurrence of the genus in New Guinea. Material was recorded from Sattelberg (located on Huon Peninsula, about 15 miles west of Finschafen), northeast New Guinea, by Gunther (1929, pp. 612, 625) in his list of described New Guinea Phasmatidae. He discussed the altitudinal ranges of various species and placed *popa* in a middle altitudinal zone of 600-1,500 meters above sea level. Later (1937, pp. 81, 96) he attempted to group the eastern New Guinea phasmatids according to faunistic provinces, and cited *popa* as belonging to the watershed of the Sepik River and the area between Astrolabe Bay and Huon Gulf. Buna is about 150 miles southeast of Huon Gulf. Nothing is known regarding the food plants. H. C. Coe, collector of the Buna specimen here recorded, reports that it was found on the ground on dead leaves that made a background of protective coloration. No other specimens of this species were seen by him or his associates.

Material examined: ♀, Buna, northeast New Guinea, December, 1943, H. C. Coe (University of Arkansas); ♀, data uncertain, apparently eastern New Guinea, A. S. Meek (A. N. S. P.); ♀, Sattelberg, vic. Finschafen, New Guinea, March, 1933, L. Wagner (M. C. Z.).

### *Extatosoma elongatum* Froggatt

#### Figure 4

*Extatosoma elongatum* Froggatt, 1922, Proc. Linn. Soc. N. S. Wales, vol. 47, pt. 3, p. 345, pl. 38.

This species was described as having more slender legs than *tiaratum*, with the expansions of the femora and tibiae narrow and arcuate. There are two double spines on the occipital crest of the head and erect, paired, median lamellae on the fifth and sixth terga. Slender, reddish-brown spines occur on the ventral surface of the abdomen. General color is deep green, "lightest on the wing pads"; mottling with grayish and dull white spots occurs on the abdomen and legs. Body length is 5 inches. The male is unknown.

McKeown (1940, 1944) has mentioned *elongatum* briefly; otherwise, no information other than that contained in the original description has come to my attention. Froggatt's type was from Gosford, New South Wales, where it was found on a brushy tree. It remained alive a week and laid more than 100 eggs. A second specimen before Froggatt was from Camden, New South Wales.

### Genus *Cotylosoma* Wood-Mason

*Cotylosoma* Wood-Mason, 1878, Ann. and Mag. Nat. Hist. (5), vol. 1, p. 102. Genotype, *C. dipneusticum* W.-M., 1878. (Monotypic.)

This is a genus to which four species are now referred, these occurring in Fiji, Tonga, Tongatabu and the New Hebrides. *Cotylosoma* is noteworthy because males have not yet been discovered, as well as for the distinctive structure of the females which have been supposed to be aquatic although there was never any foundation for that belief. The species are closely related and the comparatively few specimens in collections have not permitted a thorough study of their taxonomy. *C. dipneusticum* (fig. 6) is typical, possessing leaflike lateral metathoracic appendages and ventrally concave expansions of the terga. The latter probably serve as the basis for the generic name, meaning "cuplike body." I have nothing to add to the systematic notes on the genus by Uvarov (1935).

The supposition that certain walkingsticks are aquatic originated primarily with Murray (1866) who gave a detailed account of the habits of the Brazilian *Prisopus flabelliformis* (Stoll), based on field observations made by an unknown person in South America. Wood-Mason (1878) assumed without justification that *Cotylosoma* was similarly specialized for an aquatic life. The two genera have frequently been cited in scientific works as examples of water insects, and the false basis for this conclusion was first emphasized by C. J. Gahan (1912), although the aquatic habits of *Cotylosoma* were doubted by several entomologists, including Sharp (1895, p. 273; 1898, p. 91), at an earlier date. Gahan carefully reviewed the facts regarding each genus, analyzing Murray's treatment of *Prisopus* and showing it to be valueless. Uvarov (1935)

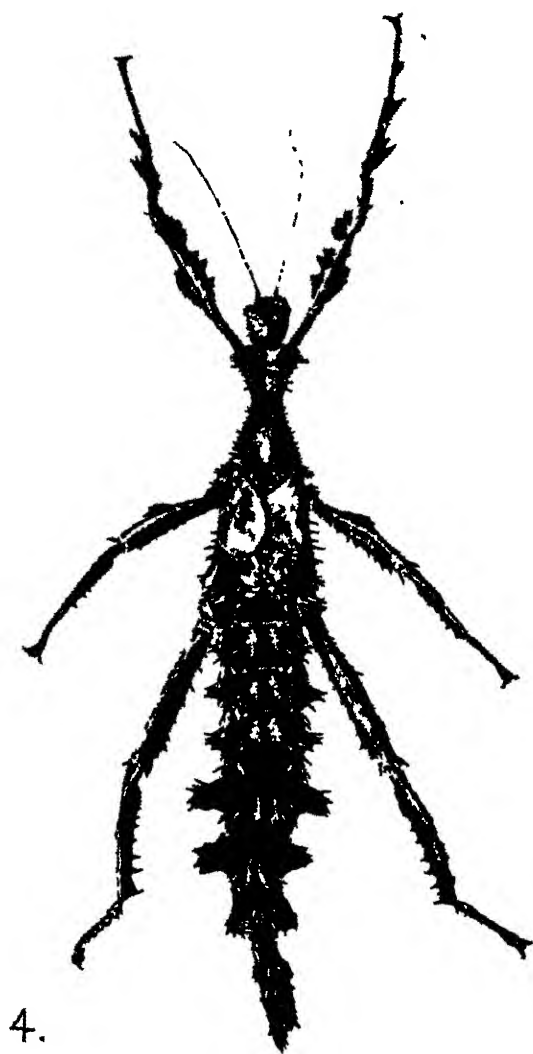


FIGURE 4. *Extatosoma elongatum* Froggatt, female, dorsal view. New South Wales. Body length, 125 mm. (After Froggatt (1922) by permission of the Linnean Society of New South Wales.)

has written an interesting and critical paper, dealing especially with *C. dipneusticum*, not only recording specimens collected far from water in the forested region of Fiji, but reporting the results of a microscopic examination of a preparation made from one of the lateral thoracic appendages. This examination failed to show any similarity between that organ and the tracheal gills of aquatic insects. The most recent authoritative review of information pertaining to aquatic Orthoptera is by Chopard (1938) who includes (p. 91, fig. 57) a copy of the drawing of the type of *dipneusticum* published by Waterhouse (1895).

As an example of the persistence of the belief that certain walking-sticks are aquatic, the recent volume on the biology of water insects by Wesenberg-Lund (1943) may be cited. *Prisopus* and *Cotylosoma* are there given as examples of aquatic insects. The native habitat of *C. dipneusticum* is said to be Borneo, the error dating back to incorrect locality data originally given by Wood-Mason but since corrected by several authors. There is no reference to the modern reviews by Gahan, Chopard or Uvarov.

An interesting test of the behavior of *C. dipneusticum* in water has been related to me by William M. Mann, director of the National Zoological Park, Washington, D. C. On December 25, 1915, Dr. Mann collected several specimens from small deciduous trees along the Navua River at Waiyanitu, on the south side of Viti Levu, the largest of the Fiji Islands. Recalling the supposed aquatic habit of the species, he placed one specimen in a pan of water, whereupon it sank to the bottom of the pan and quickly died. One of the specimens collected by Dr. Mann at Waiyanitu is recorded below. Rather than being adapted to an aquatic life, this insect is specialized so as to be camouflaged when clinging to the trunks and branches of trees, its dull brown color blending well with the bark. *C. dipneusticum* has previously been recorded only from the island of Taviuni, which is about 170 miles northeast of Kandavu.

Material of *Cotylosoma dipneusticum* W.-M. examined: ♀, Vunisea, Island of Kandavu, Fiji Islands, Wilson (U. S. N. M.). Measurements (length): Body, 92 mm.; front femur, 21 mm.; hind femur, 18 mm.; hind tibia, 16 mm.; pronotum, 6.5 mm.; mesonotum, 14 mm.; tegmen, 10.5 mm.; wing, 11 mm.; ♀, Fiji, W. M. Mann (M. C. Z.). Measurements essentially as in above specimen. Length of body, 94 mm.

#### Genus *Dryococelus*,<sup>a</sup> new genus

*Karabidion* Montrouzier, 1855, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 81. (In part.)

**Generic description**—Body large, shining, smooth except for pleurae which are smooth, tuberculate, or weakly spined; hind femur of male greatly enlarged, heavily spined; wings lacking; front femur straight at base; abdominal segments without lateral extensions. Head prognathous; eyes large; ocelli absent; antennae simple, filiform; pronotum quadrate; mesonotum elongate-rectangular; mesopleuron tuberculate; metapleuron tuberculate (female), weakly spined (male). Dorsal

<sup>a</sup>Derived from three Greek words meaning "an inhabitant of hollow trees," in allusion to the frequency with which individuals of this genus have been found in the cavities of tree trunks

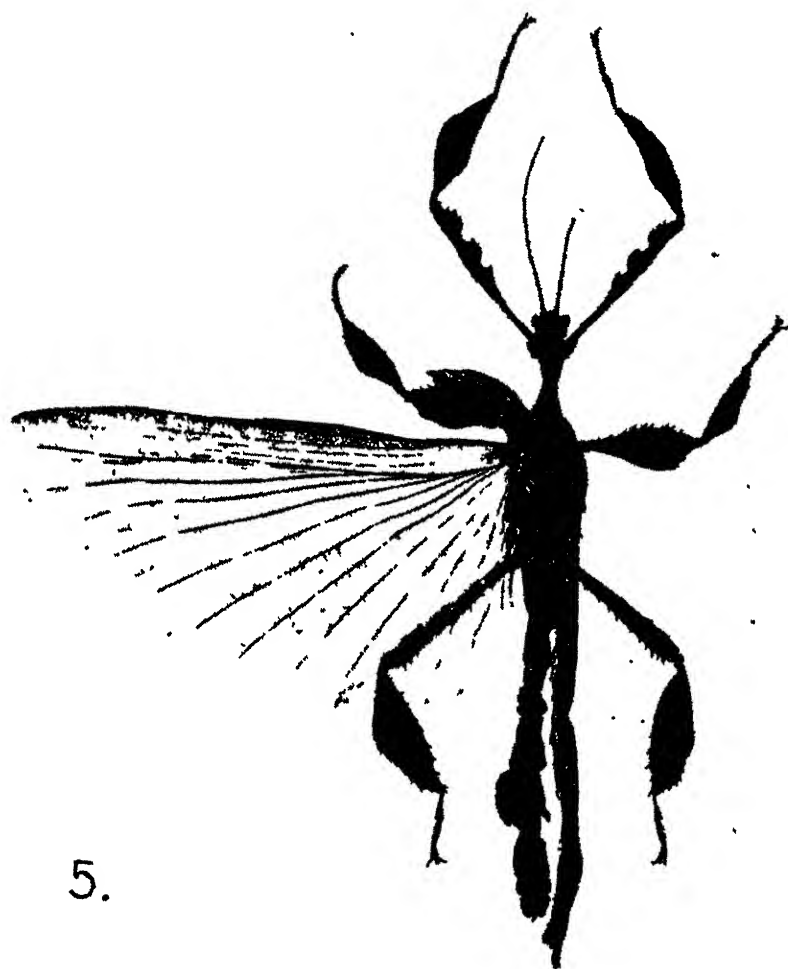


FIGURE 5. *Extatosoma tiaratum* (W. S. MacLeay), male, dorsal view. New South Wales. Body length, 83 mm.

carinae of femora (with exception of hind ones of male) feebly developed, smooth or irregular. Male hind femur with strong, basally serrate, dorsal, lateral carinae; enlarged teeth borne by ventroexternal carina; ventrolateral carinae present. Arolia moderately large. Apical tergum of male truncate or nearly so, of female short, unspecialized; female subgenital plate ventrad of apical three terga and prolonged posterior to apical tergum.

Genotype and only included species, *Karabidion australe* Montrouzier 1855, known only from Lord Howe Island.

Montrouzier (1855) proposed the name *Karabidion* to replace *Eurycantha*, as being a more appropriate name for the genus. In *Karabidion* he included *Eurycantha horrida* Boisd., the only previously known member of the genus, and three new species, among which was *K. australe*. No genotype of *Karabidion* was mentioned by Montrouzier. That *Eurycantha horrida* automatically became genotype of *Karabidion* is indicated by Paragraph f, Article 30, of the International Rules of Zoological Nomenclature: "In case a generic name without originally designated type is proposed as a substitute for another generic name, with or without type, the type of either, when established, becomes *ipso facto* type of other." Consequently, the subsequent designation by Stal (1875, p. 90) of *australe* as genotype of *Karabidion* was invalid. Thus, *Karabidion* falls as a synonym of *Eurycantha*, the genotypes being identical. *Karabidion* Redtenbacher 1907 was proposed as an emendation of *Karabidion*; this is evidenced by the crediting of the name to Montrouzier and the listing of the original Montrouzier treatment of *Karabidion* in the synonymy. Though Redtenbacher included *australe* as the only species, that has no bearing on the case as he was without the power to designate any other type for a genus that was merely an emendation of one for which a genotype had been designated. A comparable situation is covered by Opinion 120 of the International Commission on Zoological Nomenclature.

The generic complex to which *Dryococelus* belongs also includes *Thaumato bactron* Gunther 1929, *Eurycantha* Boisdual 1835 and *Canachus* Stal 1875. These may be distinguished by the following simplified key:

1. Supra-anal plate and subgenital plate of female each prolonged to form an elongate ovipositor case ..... 2
- Supra-anal plate of female not prolonged; subgenital plate prolonged or not ..... 3
2. Vestigial tegmina present (New Caledonia, Loyalty Islands, New Hebrides),  
*Canachus*
- Tegmina entirely absent (New Guinea, Bismarck Archipelago, Australia, New Caledonia, Solomon Islands) ..... *Eurycantha*
3. Subgenital plate of female not extending posterior to apical tergum; mesonotum twice as long as the greatest width and tapering anteriorly; hind tibia as long as hind femur; major ventral spines of hind femur of male borne along the midventral carina (New Guinea) ..... *Thaumato bactron*
- Subgenital plate of female prolonged posterior to apical tergum; mesonotum less than twice as long as greatest width and scarcely or not at all tapering anteriorly; hind tibia distinctly shorter than hind femur; major ventral spines of hind femur of male borne along ventroexternal carina (Lord Howe Island) ..... *Dryococelus*

#### EXPLANATION OF PLATE V

FIGURE 6. *Cotylosoma dipneusticum* Wood-Mason, female, dorsal view. Vunisea, Kandavu, Fiji Islands. Body length, 92 mm.





The genus *Paracanachus* Carl 1915 was based on *Canachus circe* Redt. of New Caledonia. This is said to differ from *Canachus* in that the posterior femur of the male is less swollen, the genicular lobe is produced into an acute spine and the median ventral carina is not spinose; certain other differences were also mentioned by Carl, such as the more slender antennae in males of *Paracanachus*, with more elongate basal antennal segments. In the absence of specimens, I cannot pass upon the validity of *Paracanachus* and have omitted it from the above key.

*Thaumato bactron* was based on *T. poecilosoma* Gunther; a second species, *mayri* Gunther, was described in 1930. The males of *Thaumato bactron* have a basally curved posterior tibia as do certain species of *Eurycantha*, and, like the latter genus, the species vary in the spination of the legs. Although body size averages much smaller in *Thaumato bactron* than in *Eurycantha*, *T. poecilosoma* (male type, 70 mm. long) is nearly as long as the smaller species of *Eurycantha*. Most species of *Eurycantha* are around 100 mm. or more in length, however, and the type of *E. portentosa* Kirby was described as being 170 mm. long.

I believe that the presence of enlarged spines on the ventroexternal carina of the hind femur of male *Dryococelus* (fig. 12), rather than on the midventral carina, as in *Eurycantha* and *Thaumato bactron*, is a fundamental generic character. The tarsal arolium is very small in *Eurycantha*, at least as represented by *E. horrida* and *E. calcarata*, though moderately large in *Dryococelus*.

#### *Dryococelus australis* (Montrouzier), new combination

Figures 10, 11, 12

*Karabidion australe* Montrouzier, 1885, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 86.

*Descriptive notes* (female)—Head with a shallow, oblique sulcus extending mesioposteriorly from posterior margin of each antennal socket; two punctures on dorsum mesially, slightly posterior to hind margin of eyes; antenna reaching about to middle of mesonotum. Pronotum with posteriorly convex transverse sulcus in front of middle; mesonotum and metanotum sparsely punctate; carinae of front and middle femora obsolete, of hind femur weakly developed, serrate; tarsi rounded dorsally; tarsal segment 5 subequal to segments 1-4 combined. Apical tergum short, narrowly rounded posteriorly, almost conelike in dorsal view; ovipositor sheath with about one-fourth length extending posterior to apex of last tergum, apical third gently, gradually curving dorsad, apex acute; cerci leaflike, projecting ventroposteriorly, laterad of ovipositor sheath.

Coloration: General color dark reddish brown, a blackish tinge on head and thorax; mesosternum and membranous coxal areas pale.

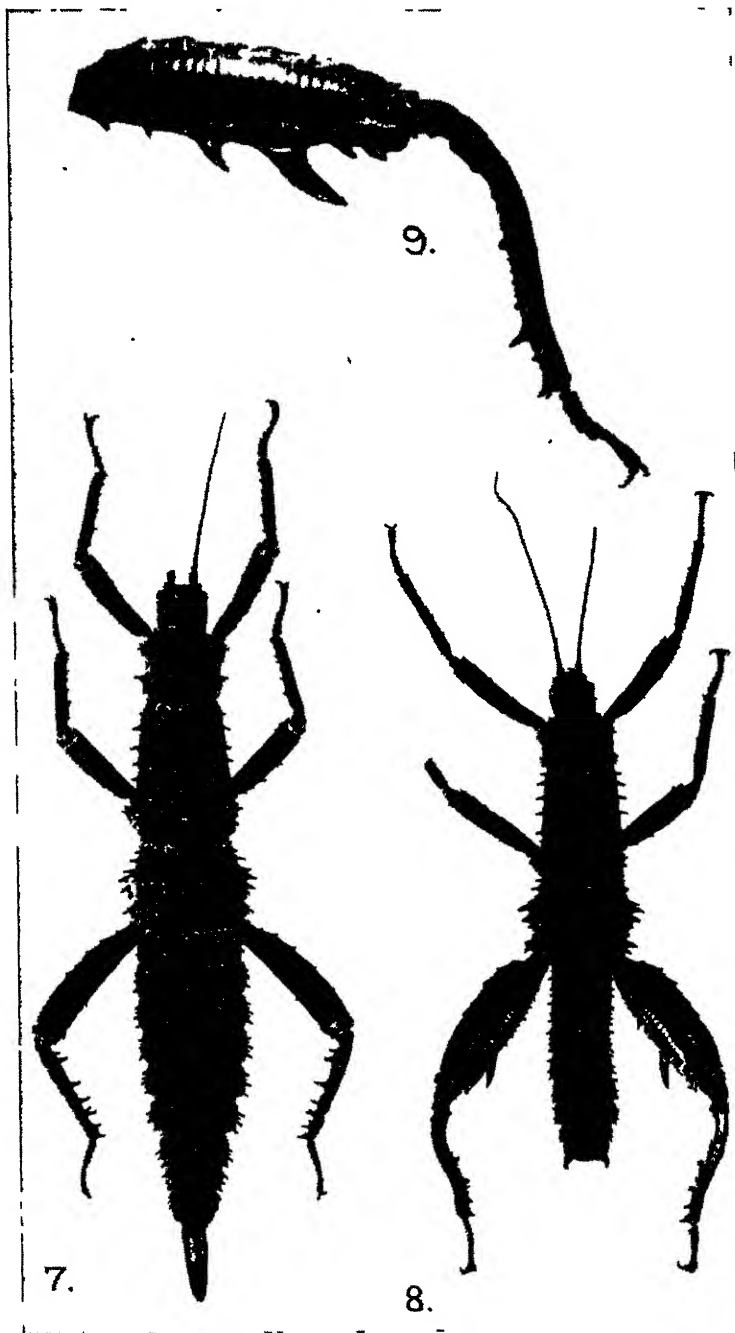
Measurements (length): Body, 120 mm.; front femur, 18 mm.; hind femur, 23 mm.; hind tibia, 18 mm.; pronotum, 12 mm.; mesonotum, 22 mm.; ovipositor sheath, 24 mm.

#### EXPLANATION OF PLATE VI

FIGURE 7. *Eurycantha horrida* Boisduval, female, dorsal view. New Guinea. Body length, 150 mm.

FIGURE 8. *Eurycantha calcarata* Lucas, male, dorsal view. Milne Bay, New Guinea, March-April, 1944. Body length, 102 mm.

FIGURE 9. Same specimen as figure 8, lateral view of external surface of left hind leg.



*Male*—Differing from female as follows: Tuberculation of mesopleuron and spination of metapleuron more developed; carinae of front and middle femora weak. Hind femur with dorsal, lateral carinae each bearing 6–12 serrations, mostly in basal third; internal ventral carina with about 5 teeth, increasing in size distally; about 8 small teeth along median ventral line, the largest midway of the length; external carina with 2 heavy, conspicuous teeth in apical half, the basal nearly twice as long as apical one, basal half of carina with 2 or 3 serrations. Hind tibia very arcuate, deeply sulcate dorsally in apical half; a median, irregularly notched ventral carina, bluntly toothed apically. Abdomen narrower and less tapering than in female; apical tergum nearly truncate, narrowly divided along middorsal line in apical half, the latero-apical angles somewhat extended posteriorly, broadly rounded; cerci thin, leaflike, extending ventroposteriorly; apical sternum blunt, feebly emarginate.

Coloration: Thorax nearly black; posterior margins of most body segments yellow.

Measurements (length): Body, 106 mm.; front femur, 18 mm.; hind femur, 32 mm.; front tibia, 16 mm.; hind tibia, 20 mm.; pronotum, 12 mm.; mesonotum, 21.5 mm.

Lord Howe Island, the sole locality for this unusual insect, is located about 500 miles southeast of Brisbane, New South Wales, and it should not be confused with a small island group of the same name located in the northeastern Solomons. It comprises a rocky island only 7 miles long, with a coral reef and enclosed lagoon. The flora is tropical (see Oliver, 1917), and the main occupation of the scant population has been the gathering of palm seeds.

Montrouzier's original material was obtained from "Mr. Want, Esquire," and he himself evidently did not visit Lord Howe, though he made field studies of species of the related genus *Eurycantha* at Woodlark Island.

Westwood (1859) has well described *australis*, and his figure of the male was reproduced by Sharp (1895). The distinctive hind leg of the male has been figured by Lucas (1872, pl. 10), and more accurately than in Westwood's figure. *D. australis* was briefly discussed by Etheridge (1889, pp. 31–33), who stated that it was called the "Tree Lobster" and that females were more numerous than males. Oliff (1889, p. 98) reported that almost every insect collection from Lord Howe contained specimens in all stages of growth.

Much the best account of the habits of this species is that of Lea (1916). He visited the island in December, 1915–January, 1916, and found *australis* very abundant in daytime resting places, especially in cavities in the trunks of living trees. Tree holes examined by Lea were in nearly all cases correlated with larval borings of a large longicorn beetle, *Agrianome spinicollis* MacL. Inhabited tree holes were seldom less than 18 inches long, sometimes much longer, and, if open at the bottom, could be detected by the presence of walkingstick excrement at the base of the tree, sometimes amounting to several bushels. Both eggs and egg shells were found among the droppings. It appeared that suitable holes might be occupied over a period of years. As many as 68 individuals were collected from a single hole, the majority being

immature. They apparently left the holes only at night to climb the trees and feed on leaves. Only an occasional nymph was beaten from shrubs during the day. Specimens with abnormally small legs, evidently resulting from injuries and subsequent retardation of growth or regeneration, were noted. Large spiders and cockroaches sometimes occupied the same holes with *Dryococelus*. Lea was told that when an occupied tree touched a house, the walkingsticks moved in and were noisy at night, especially in the case of thatched roofs.

Karny (1914, p. 9) and Ebner (1918, p. 234, fig. 3) have referred to this species under the name *Karabidion australe*, their notes being based on the same specimens from Yule Island (close to the New Guinea coast about 100 miles northwest of Port Moresby), but it is apparent from Ebner's illustrations that the material represented a species of *Eurycantha*.

A noteworthy chapter in the story of this remarkable insect has occurred during the last 30 years, due to the introduction of rats which have destroyed tremendous amounts of the animal life of Lord Howe. The destructive effect of the rats, especially on bird life, has been discussed by McCulloch (1921) and Hindwood (1938), but *Dryococelus* was not mentioned by those authors although Chopard (1938, p. 129) says that it is on the way to extermination by the rats.<sup>7</sup> Hindwood states several birds have become extinct since the rats arrived and that the introduction of the latter is usually attributed to a ship that was beached in distress in 1918. About 100 owls of several species were introduced between 1922-1930, and bounties have been paid in an effort to control the rats. It is easy to understand how *Dryococelus* would fall a prey to the inroads of rats if its habits are largely restricted to the situations described by Lea, granted of course that the rats find the insects palatable and that they spread throughout the island.

Material examined: ♂, ♀, Lord Howe Island (A. N. S. P.). Additional Lord Howe specimens at A. N. S. P. not examined.)

### Genus *Eurycantha* Boisduval

*Eurycantha* Boisduval, 1835, Voy. Astrolabe, Ent., vol. 2, p. 647. Genotype, *E. horrida* Boisduval, 1835. (Monotypic.)

*Karabidion* Montrouzier, 1855, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 81.

*Carabidion* Redtenbacher, 1907, Insektenfam. Phasmiden, Lief. 2, p. 340.

This is a genus of about a dozen species, occurring primarily in New Guinea and the Bismarck Archipelago. Adults are large and striking insects, varying from reddish brown to black, and usually with conspicuous spination. The accompanying illustrations (figs. 7, 8, 9) exemplify the two sexes. The generic name is derived from two Greek words meaning "large spine."

The only important literature dealing with *Eurycantha* since 1908 are the papers of Gunther (1929, 1930, 1932, 1933, 1937) in which synonymy and distribution are discussed. It should be noted that

<sup>7</sup>The present status of *Dryococelus* is uncertain. A note in Ward's Natural Science Bulletin (vol. 8, No. 2, p. 11, 1935) indicated that the species is extinct, but I have been informed by John W. H. Rehn, of the Academy of Natural Sciences of Philadelphia, that he has seen a recently published note suggesting that the species is maintaining itself.

Kirby (1904a) described three species, *willeyi*, *portentosa*, and *sifia*, which were omitted by Redtenbacher 4 years later.

Although specimens of *Eurycantha* are not numerous in American collections, and Montrouzier (1855) states that specimens of *E. horrida* once brought a price of 13 pounds sterling each, examples of the genus are not rare under favorable local conditions. Gunther has recorded dozens of specimens belonging to several species, though he has written little of the situations under which the material was collected. A clue to a possible method of collecting large numbers of specimens is afforded by the male of *E. calcarata* from Milne Bay recorded below, which Karl V. Krombein reports was taken during the day in a rotten stump, thereby suggesting that this species may be primarily nocturnal, spending daylight hours in shelters comparable to those occupied by *Dryococelus australis*. Bryant Rees has informed me that while on Goodenough Island, near the coast of eastern New Guinea, with American Occupation Forces in 1943, he frequently saw individuals of a large species of *Eurycantha*. A few were seen during the day crawling on the ground in clearings made for camp sites, but more were observed at night when they attracted attention by the noise of their walking over dead leaves. While no specimens were preserved, the species he encountered may well have been *Eurycantha latro* Redt., the same as discussed and illustrated by Balfour (1915). The latter described how natives of Goodenough used the hind femora of *Eurycantha* males as fish hooks. A femur was removed from the insect's body, then a string was passed lengthwise through the hollow femur and knotted outside of the trochanteral opening, resulting in a sharp hook created by the major femoral tooth. Whether bait was attached to the hook was not stated. The synonymous generic name *Karabidion* is said by Montrouzier to come from "Karabok," a native name at Woodlark Island for these walking-sticks which are eaten and compared with Crustacea. It is also similar to a Greek work meaning Crustacea.

### *Eurycantha horrida* Boisduval

#### Figure 7

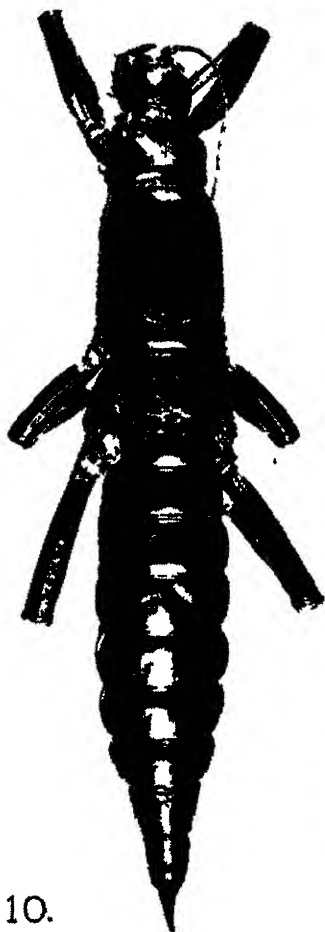
*Eurycantha horrida* Boisduval, 1835, Voy. Astrolabe, Ent., 2, p. 647, pl. 10, fig. 2.

The genotype is one of several species, the males of which have large ventral spines located on the basal third of the hind tibia. Although the conspicuous femoral enlargement and tibial curvature associated with the male sex are lacking in the female, the basic arrangement of hind tibial spines is similar in both sexes. Figure 7 is from the same female specimen illustrated by Aldrich (1921, pl. 3). This species, according to Gunther (1932, p. 788), occurs in Australia, New Guinea, the Bismarck Archipelago and the Solomon Islands.

#### EXPLANATION OF PLATE VII

- FIGURE 10. *Dryococelus australis* (Montrouzier), female, dorsal view. Lord Howe Island. Body length, 120 mm.  
 FIGURE 11. Same, male, dorsal view. Lord Howe Island. Body length, 106 mm.  
 FIGURE 12. Same specimen as in figure 11, lateral view of external surface of right hind leg.

12.



10.



11.

An egg removed from the ovipositor of one of the females recorded below agrees closely with that described by Sharp (1898, p. 85, fig. 41). It is 8 mm. long, cylindrical, rounded at each end, and grayish brown. A circular operculum forms a cap at one end, and on one side there is an ovate design, the point toward the operculum, with a crescent-shaped mark in the basal third of the design and a stemlike line at the base. The eggs of closely related species evidently do not differ markedly, as Sharp's material was not of *horrida* though so reported by him.

Material examined: ♀, "New Guinea," body length, 150 mm. (Illustrated in fig. 7.) (U. S. N. M.); ♀, "New Guinea," Dodd, body length 140 mm. (U. S. N. M.).

### *Eurycantha calcarata* Lucas

Figures 8, 9

*Eurycantha calcarata* Lucas, 1870, Soc. Ent. de France Ann., (4), vol. 9, p. XXV; *ibid.*, (5), vol. 2, p. 24, pl. 8, 1872.

The male recorded below agrees well with Lucas' original illustration, also with that of Chopard (1938, fig. 16). This species differs from *horrida* in lacking a conspicuous ventral tooth in the basal third of the hind tibia. Carl (1915) defines the distribution of *calcarata* as Australia, New Guinea, Bismarck Archipelago, the Solomons and New Caledonia, and Gunther (1933) cites its abundance in New Guinea and the Bismarck Archipelago. The New Britain material misidentified by Sharp (1898) as *E. horrida* was described as *E. willeyi* by Kirby (1904a), but Gunther (1932, p. 774) doubts that *willeyi* is distinct from *calcarata*. Sharp mentioned that a "fine series" was obtained by Willey on New Britain, and he described both eggs and nymphs.

Material examined: ♂, Milne Bay, New Guinea, in rotten stump, March-April, 1944, K. V. Krombein. Body length, 102 mm. (U. S. N. M.).

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THE THORACIC MUSCLES OF THE COCKROACH PERIPLANETA AMERICANA (L.), by C. S. CARBONELL. 23 pages, 8 plates. Smithsonian Miscellaneous Collections, Vol. 107, No. 2, 1947.

Although the cockroach has been studied extensively the author introduces his article with the statement that little has been published on its internal anatomy. He notes also that its musculature "bears little resemblance to that of other insects."

Most of the article is composed of a list of the muscles with brief descriptions of the form, origin and insertion. A preceding section, however, which discusses the mechanism of movement, will be of considerable interest to readers who are not primarily interested in the details of anatomy.

The figures are well drawn and well reproduced and do not suffer from the translucency of paper previously noted in publications of this series.—A. W. L.

## TWO NEW AMYCLE (Homoptera: Fulgoridae)

DOROTHY J. AND JOSEF N. KNULL<sup>1</sup>

### *Amycle saxatilis* Van Duzee

1914. *Trans. San Diego Soc. Nat. Hist.*, 2: 33-34.

At the request of Dr. Edward S. Ross, we hereby validate the Van Duzee selected male lectotype of this species. It is Lectotype, California Academy of Science Ent. Cat. No. 2202, locality, San Diego Co., Calif., May 21, 1913 (E. P. Van Duzee). We are indebted to Dr. Ross for sending a paratype of *A. saxatilis* for study, as well as three undetermined specimens which are included under the following descriptions.

We are grateful to Drs. John S. Caldwell and Z. P. Metcalf for information concerning this genus.

### *Amycle pinyonae* n. sp.

*Male*.—Near *saxatilis* Van Duzee but larger and with the vertex distinctly shorter than combined pro- and mesonotum.

Color: Dark mottled gray, minutely irrorate anteriorly with pale, darker on middle and apex of vertex and depressed discal area of pronotum; basal half of clypeus and a spot on lateral margin of frons pale. Elytra gray, darker on disk and humeral angles, with fine pale reticulation especially prominent on apical portion; distinct white median spot on outer claval nervure, extends diffusely, obliquely on corium. Wings fumose on outer half with many transverse fuscous veinlets, longitudinal veins also fuscous. Below, abdomen and legs heavily minutely irrorate with white round spots.

Head thin and strongly produced; vertex shorter than pro- and mesonotum together, ligulate, narrowing abruptly above eyes to middle, then gradually to broadly rounded apex; surface depressed, with deep, median, linear, finely strigate groove, margined by a pair of lateral carinae which become distinct above eyes, approach one another at middle and extend about parallel to near apex; depression between these carinae and lateral carinate margins not as deep as median, lateral carinae sharp, submargin laminate carinate; a pair of oval ocellate depressions on basal disk either side nearer eyes than middle; hind margin subtruncate; post-ocular protuberance triangular, extending to middle of pronotum. Front nearly flat, a little concave; expanded sinuately to eyes from arcuate base, narrowed above antennae, broadest just above eyes, then narrowed to broadly rounded apex; disk finely striate, carinae faint except for median longitudinal carina on apical third; clypeus convex, triangular, carinate on apical half.

Pronotum transverse, one-half length of mesonotum; anterior margin bisinuate; posterior margin feebly angularly excavated; disk depressed between median and lateral raised areas, sides also depressed;

<sup>1</sup>Contribution from Department of Zoology and Entomology, The Ohio State University.

surface finely strigate. Mesonotum feebly tricarinate; disk and apex depressed; surface finely strigate.

Elytra almost parallel to broadly rounded apices, veins prominent, reticulation especially prominent toward apices. Hind tibiae with four lateral spines.

*Female*.—Base of wings red and some reddish brown irroration on base of elytra.

Length to tip of elytra: 13.8 mm.; width, 5.4 mm.

Male *holotype* and female *allotype* taken from pinyon pine (*Pinus cembroides* var. *monophylla* Voss), Pinyon Flat, Santa Rosa Mts., Calif., May 27, 1946, 4,000 ft., by D. J. and J. N. Knull, in Collection of The Ohio State University. A female *paratype* labeled Roaring Springs, Grand Canyon, Ariz., July 30, C. C. Searl collector, in collection of California Academy of Sciences.

### *Amycle tumacacoriae* n. sp.

A greatly produced narrow head with upturned apex distinguishes this from other members of the genus, and suggests a relationship with *Scolopsella*.

*Male*.—Color and markings similar to those of *A. pinyonae*.

Head thin, narrow, very strongly produced; vertex distinctly longer than pro- and meso-notum together, ligulate, narrowing sinuately from base with a slight bulge on median third and again on rounded apex; surface depressed with a very narrow median groove, broader on basal third, then linear to apex, margined by sharp carinae, area between median and lateral carinae depressed, except for convexity before apex, and sharply upturned apex which arises at more than a right angle; submargin laminate, carinate; hind margin bisinuate; a pair of ocellate depressions either side near base midway between eyes and center. Front flat basally, becoming decidedly convex on apical half, with distinct median and lateral carinae; base slightly excavated; sides to above eyes sinuate, indented at ocelli, narrowed obliquely from above eyes to middle where it is about half basal width, bulging slightly, then narrowing to rounded apex; post ocular protuberance triangular; disk finely striate especially on basal half. Clypeus long, triangular, convex and with strong median carina on apical half.

Pronotum transverse, less than half length of mesonotum; anterior margin bisinuate; posterior margin broadly emarginate; depressed on anterior half, a median and strong lateral carinae; sides depressed; disk finely strigate. Mesonotum tricarinate basally, anterior submargin and lateral angles tumid; surface finely strigate; apex depressed.

### EXPLANATION OF PLATE I

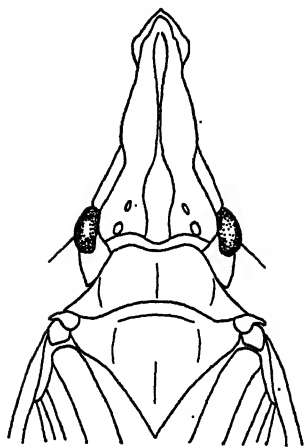
#### *Amycle tumacacoriae* n. sp.

1. Dorsal view of head.
2. Lateral view of head.
3. Front view of head.
9. Male genitalia.

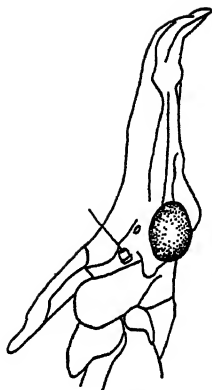
#### *Amycle pinyonae* n. sp.

4. Dorsal view of head.
5. Lateral view of head.
6. Front view of head.
7. Male genitalia.
8. Female genitalia.

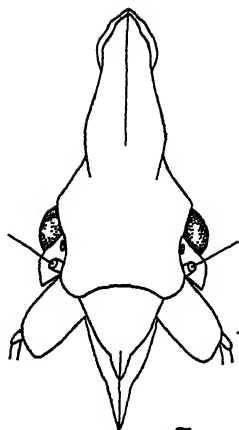
All genitalia drawn under higher magnification.



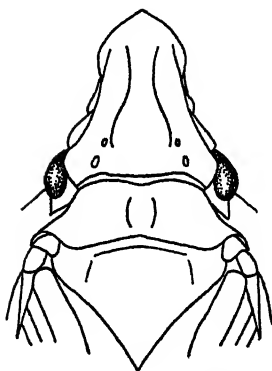
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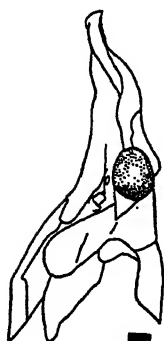
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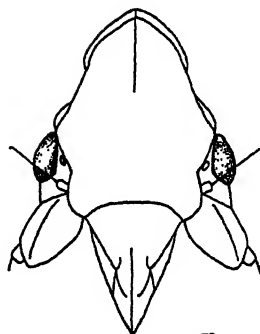
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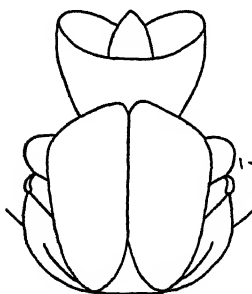
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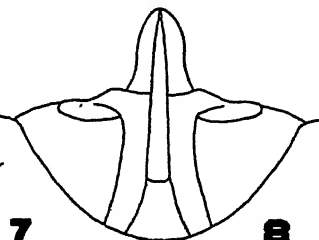
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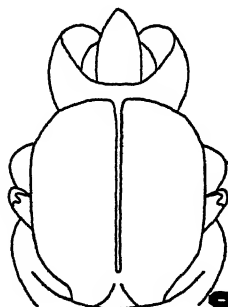
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7



8



9

D.J. & J.N.K.

Elytra narrow, sides straight, apices subangulate, flared on inner margin behind apex of clavus. Hind tibiae with four lateral spines.

Length to tip of elytra: 15.8 mm.; width, 5.7 mm.

*Holotype* male labeled Tumacacori Mts., Ariz., July 22, 1940, collected on dead branch of oak by D. J. and J. N. Knull, in collection of The Ohio State University. Male *paratypes* labeled Nogales, Ariz., October 8, 1898, Koebele, Koebele Collection, and Chisos Mts., Big Bend National Park, Tex., July 6, 1946, E. C. Van Dyke, in collection of California Academy of Sciences.

FRAGMENTS OF ENTOMOLOGICAL HISTORY, PART II, by HERBERT OSBORN. x+232 pages, 36 plates. Published by the Author, printed by the Spahr and Glenn Company, Columbus, Ohio, 1946. Price \$2.75.

Doctor Osborn's *Fragments of Entomological History* is a priceless collection of material which could have come from no other pen than that of our beloved Nestor of the science. His long active life has given him an unequalled contact with entomologists and entomology during its gradual development in America and his devotion to professional interests has enabled him to share this personal knowledge in the unique *Fragments*. Few men may equal the span of his experience and of those few, still less may combine the varied qualities needed for the production of such a work.

The second volume of the *Fragments* is dedicated to Mrs. Osborn (1858-1939) and carries her photograph as a frontispiece, followed by a memorial page bearing the resolution of the Society at the time of her passing. One reads between the lines here to see the long and fine relationship which the author enjoyed in his home and to appreciate its importance in the career of an eminent scientist. As he thinks of his old and valued friend, the reviewer is forced here to revise his impulse to pay tribute to the work of Doctor Osborn and to hail instead the accomplishment of Doctor and Mrs. Osborn together.

From the Spahr and Glenn Company, the book carries a foreword of tribute to the Author.

The book includes chapters on Research Agencies, College Instruction in Entomology, Entomological Societies, International Entomological Congresses, Publications, Personal Mention, Commemorative Events and Memorials, Buildings and Equipment for Insect Study, Insecticides and Machinery, Insect Collections and Regional Notes, followed by addenda, corrections and additions for Part I and illustrations.

The material included is necessarily detailed, concise and factual. Little can be said of it in summary since it is already terse, but to reiterate that it represents a long life of personal acquaintance with the matters covered and that, as a result, it embodies a wealth of information which might, in ordinary publications, be lost to the scientific world. No entomologist can fail to find in it an immense store of helpful and interesting data—data on the resources of the science, data on progress of the past, data on the lives and experiences of other entomologists,—and with them the reassurance that comes from knowing that he does not work alone but that his problems and difficulties are such as have been experienced by others and that he too may contribute some valuable mite to the tremendous science in which he has chosen to spend his professional life.

The *Fragments* deserve a place on every entomologist's bookshelf. It will occasionally be valuable for specific reference, but more than that, it will serve to correlate the many decades of entomology as few books can. We congratulate the author on the completion of the work at an age when most men would be content to rest on accomplishments of the past and to spend their days in less productive efforts.—A. W. L.

# TARSAL CHEMORECEPTORS OF THE HOUSEFLY AND THEIR POSSIBLE RELATION TO DDT TOXICITY<sup>1</sup>

WM. P. HAYES AND YU-SU LIU  
University of Illinois

Chemoreceptive sensilla are associated with the functions of taste and smell. These are found on various parts of the body such as antennae, palpi and tarsi. Those on the tarsi are usually considered to be gustatory in function and in several species of Lepidoptera have been shown to be most sensitive to sugars. Chemoreceptive sensilla are of various types. Those associated with small, slender hairs have delicate walls and are supposed to be receptive to odors and are distinguished as chemoreceptive hairs. They fall in the category of sensilla called *sensilla trichodea*. Such hairs are innervated by a group of sense cells and not by a single bipolar sense cell as are the trichodea sensilla that are regarded as organs of touch. According to Wigglesworth (1939, p. 150), these thin-walled sensilla have no socket or trichopore at their base. The tormogen cell is often absent although the trichogen cell is usually large and secretes a product that fills the thin-walled hair. The sense cells are usually many in number and may form clusters of twenty or thirty. They are enclosed in a nucleated coat which is continuous with the neurolemma of the attached nerves. The proximal nerve being the afferent process and distal nerve forms the terminal filament.

The only histological study of tarsal chemoreceptive organs known to the writers is that of Eltringham (1933, p. 33) on the tarsal organs of the butterfly, *Vanessa (Pyrameis) atalanta* (Linn.). Since DDT is known to be a nerve poison, which has been shown by Roeder (1946) to act through the leg nerves of the cockroach, it was suggested to the writers by Prof. C. W. Kearns that a study of the peripheral nerve of the tarsus might throw some light on the mode of action of DDT. It was therefore planned to compare histologically the structures of a tarsus of an insect susceptible to DDT with some that were not susceptible to it. Accordingly, sections were made of the tarsus of the housefly, *Musca domestica* L., the German cockroach, *Blattella germanica* (L.), and the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Muls. The housefly is easily killed with DDT while the German roach and the larva and adult of the Mexican bean beetle are not so susceptible to its action.

## REVIEW OF LITERATURE ON CHEMORECEPTIVE SENSIBILITY OF THE INSECT TARSUS

The chemoreceptive sensibility of insect tarsi has been shown by many workers. Minnich (1921) first proved functionally the presence of chemoreceptors on the tarsi of two nymphalid butterflies. Minnich

<sup>1</sup>Contribution No. 274 from the Entomological Laboratories of the University of Illinois, Urbana.

(1922 and 1929) further found in various groups of insects, especially blowflies, that it was necessary for the tarsi to come into direct contact with the material before a response was initiated. Weiss (1930) has verified the presence of contact chemoreceptors on the tarsi of the Admiral butterfly. Anderson (1930) has obtained evidence of similar receptors in the Monarch butterfly. Crow (1932) and Marshall (1934) worked on Calliphoridae and the honey-bee respectively. Both of them have confirmed the presence of chemoreceptive sensibility of the legs of those two insects. McIndoo (1934) concludes from the results of his experiments that responses of blowflies to tarsal stimulations by sucrose are of an olfactory nature rather than a gustatory nature. He further reported that only nine olfactory pores occur on the tarsi of butterflies. These olfactory pores are termed campaniform organs and are not the same structures as the chemoreceptive organs described in this paper. Campaniform organs are now thought to be proprioceptive organs. Although Verlaine (1927) disagreed with some of Minnich's results, yet Deonier and Richardson (1935) supported the latter basing their opinion upon experiments on the housefly and assumed that responses of the housefly to the sugars result from stimulation of chemoreceptive organs. After proving the presence of chemoreceptive organs on the tarsi by experimental means, Eltringham (1933) worked on the organs by histological methods and described their structure in the butterfly, *Vanessa (Pyrameis) atalanta*. This is the only histological study on insect tarsal chemoreceptors so far as the writers are aware.

#### MATERIALS AND METHODS

During the course of this study, three species of insects have been selected and used. The housefly, *Musca domestica* L., is known as one of the insects most susceptible to DDT, while the German cockroach, *Blattella germanica* L., and both the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Muls., are recorded as less susceptible insects. In preparing the sections, legs were dissected and fixed in Bouin's fluid for twenty-four hours and then the general paraffin method was followed. Nevertheless, the chitinous exoskeleton of insects has in many cases made the general paraffin method impracticable. It has been proposed by many authors that the double imbedding or triple imbedding method be used, or to soften the sclerotized exoskeleton by chemical means, however, none of these methods is one hundred per cent satisfactory.

Since the junior writer has had more experience with the paraffin method, she did not follow the other methods in this study. But both the infiltration and imbedding periods were greatly prolonged in insuring a complete penetration of paraffin into the insect tissues through the thick sclerotized exoskeleton. Fortunately the results were found successful. Various kinds of stains have been tried, only Heidenham's iron haematoxylin, counterstained with eosin, was found satisfactory and Cajal's silver nitrate stain is good for nerve endings. Sagittal, frontal and transverse sections were made in series from six to seven microns thick. For study of the external structures, *in toto*, mounts were prepared and stained with methylene blue. Specimens of different

sexes were compared and special attention was also paid to the three different pairs of legs of the insect. No essential differences were found in the sexes or the different pairs of tarsi.

#### HISTOLOGY OF THE HOUSEFLY TARSUS

The tarsi (Fig. 9) are composed of five segments or tarsomeres, the first segment is the longest, the second and the fifth are subequal, and the third and fourth are the shortest. The pretarsus is located on the distal end of the fifth tarsal segment. It consists of a pair of claws and a pair of large basolateral lobes associated with the underside of the claws which are known as the pulvilli. At the bases of the claws and pulvilli two small sclerites, the planta and unguitracractoral plate, are located. No muscles are to be found in the tarsi. Numerous hairs cover the surface of the tarsi.

*Cuticula* (Fig. 16)—The cuticula itself has a stratified appearance in sections, it contains two distinct principal layers, namely, the exocuticula (Fig. 16, EXCU), and the endocuticula (Fig. 16, ENCU). While on the exterior there is a very thin surface layer, or epicuticula (Fig. 16, EPCU) which appears in sections as a clear border line. The exocuticula is distinguishable from the endocuticula by its darker pigmentation and its denser structure. Measurements of the cuticula show it to be from 12.5 to 25 microns thick.

*Hypodermis* (Figs. 9 and 17, HP)—The hypodermis or epidermis is composed of ectodermal cells arranged in a single layer. However, a few exceptions are found in which the cells are arranged into two layers (Fig. 1, HP<sub>1</sub>) or disposed irregularly (Fig. 15, HP). The shape of the cell is cubical or columnar, the latter shape has only been found on the lateroventral sides of the second tarsal segment (Fig. 17, HP) and the distal part of the first tarsal segment.

At the distal end of the fifth tarsal segment, a layer of hypodermal cells extends towards the unguitracractoral tendon forming a cone-shaped structure that embraces the tendon (Figs. 1 and 24, HP<sub>2</sub>).

*Basement membrane* (Fig. 1, BM)—The membrane is very thin and closely adherent to the hypodermis.

*Unguitracractoral tendon* (Figs. 1, UT, and 11)—It is known that no intrinsic muscles exist in the tarsi. A cord-like tubular tendon extends throughout the five tarsal segments. It arises from the unguitracractoral plate of the pretarsus. The so-called tendon is probably an apodeme of the unguitracractoral plate. It is composed of a bundle of tendon fibrils and thin hypodermal cells externally. From a cross-section of the tendon (Fig. 13), it is observed to be a hollow tube surrounded by two distinct layers of which the central ring is thicker and darker.

*Trachea* (Figs. 2 and 9, TR)—Along the side of the unguitracractoral tendon there is a trachea running throughout the five tarsal segments which ends in many small tracheoles near the distal hypodermis of the fifth tarsal segment. Intima and taenidia of the trachea are visible.

In a sagittal section of the first tarsal segment (Fig. 2, TG) a spindle-shaped gland is found which connects with the trachea by two thread-like prolongations of its ends. Eltringham (1932) has described a "tendon-gland" in the tarsus of *Vanessa (Pyrameis) atalanta* which is very much like that found in the housefly. The writers have carefully



traced the connections of this so-called gland and there seems to be no connection with the tendon. It seems more reasonable to call it a tracheal gland (Fig. 2, TG) although we cannot suggest its function.

*Nerves* (Figs. 9, NV; 10 and 12)—Two nerves run along the inside of the hypodermis throughout the five tarsal segments. One of them is associated closely with the trachea (Fig. 12, NL). A thin layer of nucleated neurolemma (NL) is distinct. The two nerves run much closer together and become coarser in the second tarsal segment than they are in the remaining segments. While in the first tarsal segment the two nerves become almost combined into a single stout nerve (Fig. 15, NV). Many small nerve branches are found at the distal part of each tarsal segment which connect with the hypodermal cells (Fig. 9).

*Connective tissue* (Figs. 15, 18, and 19, CN)—Connective tissue is present in spaces around the unguitractoral tendon (UT) and the nerves (NV). It is a noncellular membrane. In a cross section of the first tarsal segment the tissue seems to form a cylindrical membrane surrounding the tendon (Fig. 14, CN). In the second tarsal segment the connective tissue extends to connect with two nerves. In the third and fourth tarsal segments (Fig. 19) the cylindrical membrane has disappeared and only two short stripes of tissue (CN) connect between the tendon and the nerves. While in the fifth tarsal segment, the connective tissue is present between the nerves only and lies dorsad of the tendon (Fig. 23, CN). The layer of connective tissue apparently divides the tarsus into two distinct sinuses which are filled with blood cells and thus separates the outgoing and returning blood streams.

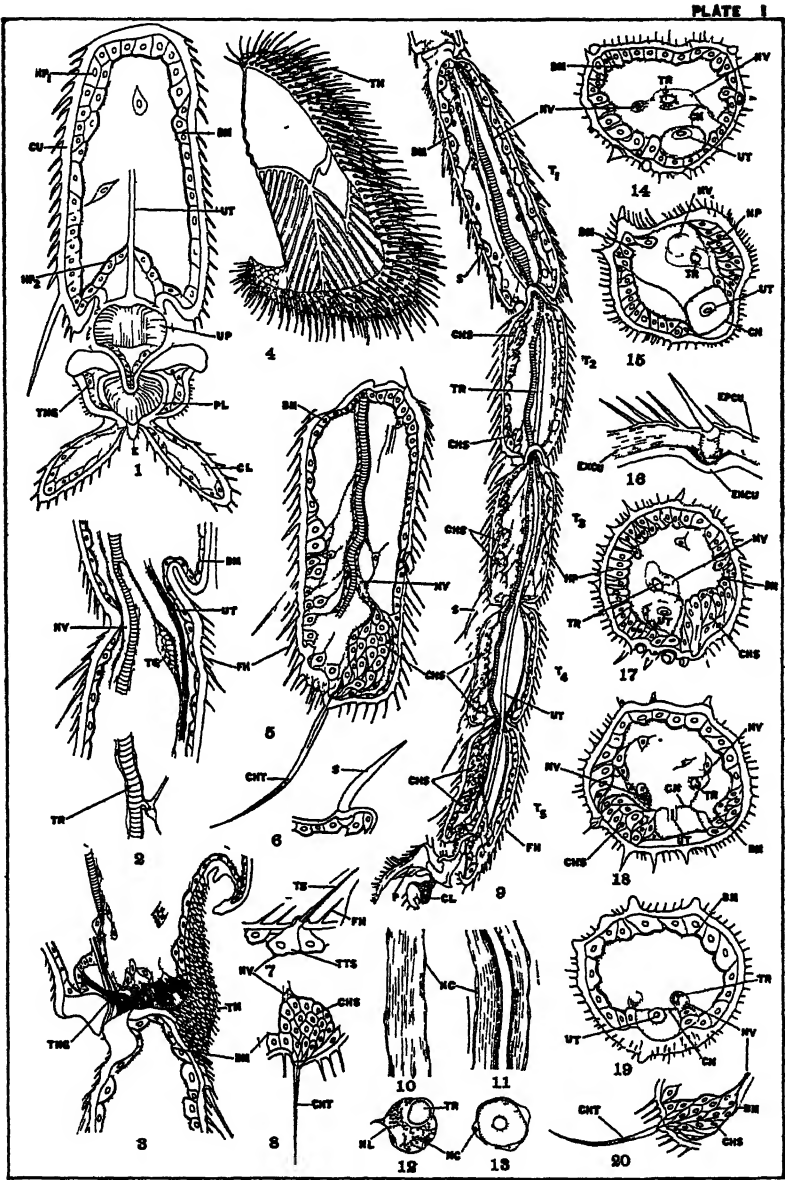
*Sense organs*—Two different types of peripheral sense organs exist in the tarsi of the housefly, namely, the tactile sensilla and chemoreceptive sensilla. No campaniform sensilla are to be found in the tarsus but they do occur in the tibia.

a. *Tactile sensilla* (Fig. 7, TTS)—These are bipolar nerve cells in an intraepidermal position. The shape of the cells is not very regular and their size is almost one and one-half times as large as other hypodermal cells. The distal process of each cell is attached to the base

#### EXPLANATION OF PLATE I

Housefly, *Musca domestica* L.

Fig. 1. Frontal section of fifth tarsal segment and pretarsus. 2. Sagittal section of the proximal end of first tarsal segment, showing tracheal gland. 3. Sagittal section at the junction of the tibia and first tarsal segment, showing the tenent hairs. 4. Frontal section of pulvillus. 5. Sagittal section of the fourth tarsal segment, showing the chemoreceptive sensilla and seta. 6. Sagittal section of a spine. 7. Sagittal section of fixed hairs and tactile sensillum and its seta. 8. Cross section of a portion of the tarsal segment, showing the chemoreceptive sensilla. 9. Sagittal section of tarsus. 10. Longitudinal section of tarsal nerve. 11. Longitudinal section of unguitractoral tendon. 12. Cross section of tarsal nerve. 13. Cross section of unguitractoral tendon. 14. Cross section of first tarsal segment. 15. Cross section of second tarsal segment, showing the irregular arrangement of hypodermal cells. 16. Section of cuticula. 17. Cross section of second tarsal segment, showing the columnar hypodermal cells. 18. Cross section of second tarsal segment, showing the chemoreceptive sensilla. 19. Cross section of third tarsal segment. 20. Longitudinal section of a portion of tarsal segment, showing the chemoreceptive sensilla.



of a tactile seta which is long and thin-walled (Fig. 7, TS). The cell is innervated on both ends, one nerve connecting with the longitudinal tarsal nerve and the other attached to the sensory seta. The tactile sensilla are found scattered around on all sides of the tarsal segments, however, they are fewer in number on the dorsal side, but more numerous on the distal end of each segment, especially in the first tarsal segment.

b. *Chemoreceptive sensilla* (Figs. 8, 9, 20 and 22, CHS)—These are groups of sensory cells in a subepidermal position covered by a nucleated neurolemma continuous with that of the longitudinal nerve. The individual cells are more or less spindle-shaped. The distal end of the sensilla is attached to a thin-walled, long seta, known as the chemoreceptive seta (Fig. 8, CHT), and a nerve fiber can be traced from the sensilla to the center of the connecting seta. The proximal end of the sensilla is provided with a bundle of nerve fibers which connects with the longitudinal tarsal nerve (Fig. 8, NV). The chemoreceptive sensilla are located lateroventrad on the second to fifth tarsal segments. They have not been found either on the dorsal side of these segments or in the first tarsal segment. In the second tarsal segment (Fig. 9, CHS), only two chemoreceptive sensilla are found. These are located near the proximal and distal ends but not in a symmetrical position. In the third tarsal segment many chemoreceptive sensilla are found in the lateroventral area which occupy almost two-thirds of the length of the whole segment starting from the distal end. In the fourth tarsal segment, the chemoreceptive sensilla are even more numerous than those of the third tarsal segment. They occupy three-fourths of the length of the whole segment. While in the last tarsal segment, chemoreceptive sensilla are found only in the middle portion of the segment where they occupy about half the length of the segment.

*Cuticular appendages*—There are five different kinds of cuticular appendages on the tarsi of housefly, namely, spines, fixed hairs, tenent hairs, tactile setae and chemoreceptive setae.

a. *Spines* (Figs. 6 and 9, S)—These are stout, short, compact and curved structures scattered around on the surface of the tarsal segments. They are quite numerous on the first tarsal segment.

b. *Fixed hairs* (Figs. 7 and 9, FH)—These are the shortest appendages of the tarsal segments. They are soft, fine and numerous.

c. *Tenent hairs* (Figs. 3, 4, and 25, TH)—The tenent hairs on the pulvilli are long and slender hairs with movable bases which lead to the fine channels inside (Fig. 4). What appear to be tenent hairs are found on the junction of the tibia and first tarsal segment (Fig. 3, TH). They are very short with large bases and are provided with fine channels inside. The writers are unaware of these structures ever having been noted before.

d. *Tactile setae* (Fig. 7, TS)—These are long, fine, thin-walled setae provided with an articulating joint at the base. Each tactile seta is connected with a bipolar tactile sensillum (Fig. 7, TTS).

e. *Chemoreceptive setae* (Figs. 5, 8, and 9, CHT)—These setae connect with the chemoreceptive sensilla. When compared with the tactile seta, the former are much longer and comparatively more slender. At the base of the seta is a distinct joint. The wall of the seta is thin. Inside of it is a visible nerve fiber connected with the chemoreceptive sensilla.

*Pretarsus* (Fig. 25, PT)—At the distal end of the fifth tarsal segment is the pretarsus which is composed of an unguitracal plate (Fig. 1, UP), a sclerotized planta (Fig. 1, PL), a pair of claws (Fig. 1, CL), a pair of pulvilli (Fig. 1, P), and a short empodium (Fig. 1, E).

a. *Unguitracal plate* (Fig. 1, UP)—The unguitracal plate is divided into two sclerites, the distal one is distinguished as the planta (Fig. 1, PL). These are two heavily sclerotized, striated plates. Hypodermal cells are present in each distal end (Fig. 25). The cells in the planta are large and connected with the channels of the pulvilli. They are believed to be the tenent gland cells (Fig. 1, TNG).

b. *Claw* (Fig. 1, CL)—The claw is a hollow structure containing a layer of hypodermal cells. On the outside of the claw, there are many short, fine spines.

c. *Pulvillus* (Fig. 4)—The pulvillus is a hollow membranous structure with numerous internal channels. On the surface of the membrane there are numerous fine tenent hairs (Fig. 4, TH).

d. *Empodium* (Fig. 1, E)—The empodium is a small swollen sclerotized portion on the distal end of the pretarsus between the pulvilli. The structure is hollow inside and no cells are found in it.

#### HISTOLOGY OF THE ADULT MEXICAN BEAN BEETLE TARSUS

The tarsi (Fig. 27) are four-segmented, the fourth segment is the longest, the first shorter than the fourth, but stouter, the third is the shortest, while the second is an oblique elongate segment which is strongly developed transversely in the distoventral direction. The surface of the tarsus is covered with numerous fine hairs. However, it is characteristic that the venters of the first and second segments have rows of long and fine tenent hairs (Figs. 27, 30 and 31, TH), which do not appear on the dorsal surface and the remaining segments. The distal end of the tarsus bears the pretarsus which includes an unguitracal plate and a pair of claws.

*Cuticula* (Figs. 26 and 27, CU)—The epicuticula (Fig. 26, EPCU) is a yellowish border line, while the exocuticula (Fig. 26, EXCU) and the endocuticula (Fig. 26, ENCU) are two thicker layers. The former can be distinguished by the darker and denser structure. The measurements of the cuticula are from 25 to 45 microns thick.

*Hypodermis* (Figs. 31, HP)—The hypodermis is a single layer of cubical cells. It is quite uniform in appearance throughout all of the four segments. Nevertheless, on the venter of the first and second segments columnar cells are found. The columnar cells are glandular cells which are larger in size and each is located at the base of a tenent hair (Fig. 30, TH).

*Basement membrane* (Figs. 27 and 28, BM)—The membrane is very thin and adheres closely to the hypodermis.

*Unguitracal tendon* (Figs. 27, UT and 29)—A long, tubular tendon runs throughout the four tarsal segments. It starts at the unguitracal plate of the pretarsus. In a cross section of the tendon, it is seen to be a hollow tube. (Fig. 32, UT.)

*Trachea* (Fig. 27, TR)—Along the dorsal side of the unguitracal tendon there is a large trachea running throughout the four tarsal segments. Intima and taenidium are very distinct.

**Nerves** (Fig. 27, NV)—A pair of nerves is present. The dorsal one runs along the side of the hypodermis and another is associated with the trachea. They become closer and closer to each other at the proximal part of the tarsus. Nerve fibers are found connected with the hypodermal cells at the distal end of the tarsus.

**Connective tissue** (Fig. 31, CN)—The spaces between the nerves and trachea are connected with loose connective tissue which separates the blood stream. Many large oenocytes are found in the blood.

**Sense organs** (Fig. 28, TTS)—Tactile sensilla are found only on the distal end of the third and fourth tarsal segments. They are scattered. Each is connected to a long, tactile seta. No chemoreceptive sense cells are present.

**Cuticular appendages**—There are three different types of cuticular appendages located on the tarsal surface, namely, fixed hairs, tenent hairs and tactile setae. These may be distinguished as follows:

a. **Fixed hairs** (Figs. 26 and 33, FH)—Fixed hairs are the short hairs which are scattered over the surface of all the tarsal segments.

b. **Tenent hairs** (Figs. 27 and 30, TH)—These long curved hairs are found only on the ventral surface of the first and second tarsal segments and are arranged into rows. They are long and slender with a follicle-like structure at the base which is imbedded in the cuticula. Each tenent hair is connected inside with a tenent gland cell (Figs. 27 and 30, TNG).

c. **Tactile setae** (Fig. 28, TS)—A number of tactile setae are scattered over the venter of the distal end of the third and fourth tarsal segments, each is connected with a tactile sensillum by a fine nerve fiber.

**Pretarsus**—An unguitractoral plate (Fig. 27, UP) is located at the distal end of the fourth tarsal segment. On the venter of the unguitractoral plate are numerous fine, short, scale-like structures. In the cavity within the unguitractoral plate, loose and irregular hypodermal cells are found. A pair of hollow claws is situated distad of the unguitractoral plate (Fig. 27, CL). A layer of elongate hypodermal cells is found within the claws.

## EXPLANATION OF PLATE II

### Housefly, *Musca domestica* L.

Fig. 21. Cross section of third tarsal segment, showing the chemoreceptive sensilla. 22. Cross section of fourth tarsal segment, showing the chemoreceptive sensilla. 23. Cross section of the proximal end of fifth tarsal segment. 24. Cross section of the distal end of fifth tarsal segment. 25. Longitudinal section of pretarsus.

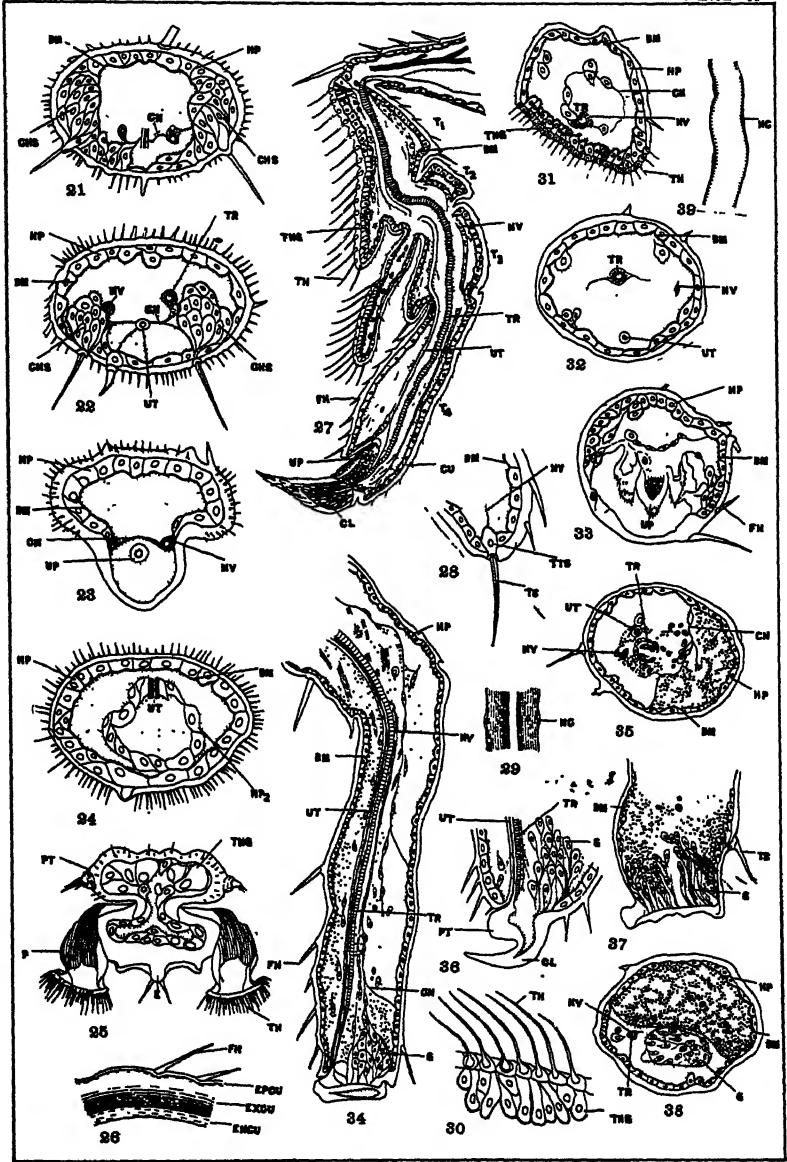
### Mexican bean beetle adult, *Epilachna varivestis* Muls.

Fig. 26. Section of cuticula. 27. Sagittal section of tarsus. 28. Longitudinal section of a portion of tarsus showing the tactile sensillum and seta. 29. Longitudinal section of unguitractoral tendon. 30. Tenent glands and hairs. 31. Cross section of first tarsal segment. 32. Cross section of fourth tarsal segment. 33. Cross section at the junction of the distal end of the fourth tarsal segment and pretarsus.

### Mexican bean beetle larva, *Epilachna varivestis* Muls.

Fig. 34. Sagittal section of tibiotarsus. 35. Cross section of the proximal end of the tibiotarsus. 36. Sagittal section of pretarsus. 37. Longitudinal section of the distal end of the tibiotarsus. 38. Cross section of the distal end of the tibiotarsus. 39. Longitudinal section of trachea.

PLATE II



## HISTOLOGY OF THE MEXICAN BEAN BEETLE LARVAL TIBIOTARSUS

The tarsus of the Mexican bean beetle larva is fused with its tibia and known as a tibiotarsus. On the distal end of the tibiotarsus is a pretarsus which includes a very short well-sclerotized segment and a single claw. Covering the surface of the tibiotarsus are many long and short setae which occur more abundantly on the ventral side.

*Cuticula* (Fig. 43)—The epicuticula (EPCU), exocuticula (EXCU), and endocuticula (ENCU) are easily distinguishable in the sections. On the surface of the cuticula there are many setae. The measurements of the cuticula are from 15 to 40 microns thick.

In one preparation, two distinct layers of cuticula are seen; it is quite possible that the insect was in an ecdysis stage and the exterior layer is the old cuticula (Fig. 42, CU<sub>1</sub>) while the interior one is the new cuticula (Fig. 42, CU<sub>2</sub>).

*Hypodermis* (Fig. 34, HP)—A single layer of cubical epithelial cells is seen in the longitudinal section; however, they appear as squamous cells from the surface view (Fig. 41). In one preparation in which the insect probably was in an ecdysis stage, the hypodermal cells are quite loose, not arranged into a continuous layer, but irregularly and separately situated from each other underneath the cuticula. Among these loosely arranged hypodermal cells, the space is filled with numerous blood cells.

*Basement membrane* (Fig. 34, BM)—The basement membrane is very distinct in the preparations.

*Unguitractoral tendon* (Figs. 34 and 45, UT)—A hollow tendon arises from the base of the pretarsus and extends throughout the tibiotarsus. In a cross section of the tendon, a darker ring is visible near the center (Fig. 44).

*Trachea* (Figs. 34 and 39)—There is a trachea running throughout the tibiotarsus and ending at the unguitractoral plate. Intima and taenidia are visible.

*Nerves* (Figs. 34, 35 and 38, NV)—A pair of very fine nerves runs along the hypodermis throughout the tibiotarsus. Many nerve fibers communicate with the hypodermal cells.

*Connective tissue* (Fig. 35, CN)—The connective tissue is a non-cellular membrane dividing the tarsus dorsoventrally. On the dorsal side of the membrane, the size of the blood cells is evidently much larger than those of the ventral side.

*Sense organs*—Only a few tactile sensilla (Fig. 40, TTS) are found. The hypodermal sense cells are connected with external tactile setae (Fig. 40, TS) by fine nerve fibers. This kind of hypodermal sense cell is spindle-shaped and comparatively larger than the ordinary hypodermal cells.

*Gland* (Figs. 34, 36 and 37, G)—A group of elongate cells is found at the dorsodistal end of the tibiotarsus. They are believed to be gland cells because of their appearance, but their function is unknown.

*Cuticular appendages*—There are two different types of cuticular appendages on the tibiotarsus. One is the tactile seta (Fig. 40, TS) which is thin-walled with a joint at base and longer than the other type. The tactile setae are found mostly on the distal end of the segment. Another is the fixed hair (Figs. 34, 42, and 43, FH) which is

shorter than the tactile seta. The fixed hairs are found more abundantly on the ventral side of the segment.

*Pretarsus* (Fig. 36, PT)—At the distal end of the tibiotarsus there is a well-sclerotized oval plate connected with a single claw (Fig. 36, CL). The claw is very stout and strongly curved.

#### HISTOLOGY OF THE GERMAN COCKROACH TARSUS

The tarsi of the German cockroach (Fig. 51) are composed of five segments; the first segment is the longest, the fifth is shorter than the first, the second is again shorter than the fifth, while the third and fourth are subequal and much shorter than the rest. The surface of the tarsal segments is covered with many spines and hairs. The pretarsus consists of an unguitractoral plate, a pulvillus, and a pair of large claws.

*Cuticula* (Fig. 47)—The epicuticula (EPCU), exocuticula (EXCU) and endocuticula (ENCU) are very distinct. The epicuticula is thin and yellowish in color. The exocuticula is thicker and darker than the endocuticula. The measurements of the cuticula are from 60 to 90 microns thick.

*Hypodermis* (Fig. 56, HP)—The hypodermal cells are arranged in a single layer and quite uniformly cubical-shaped. However, a layer of spindle-shaped cells (Fig. 46, HP) is found at the ventrodistal end of all the tarsal segments which is provided with distinct connective fibers that connect with the unguitractoral tendon. Since there is neither an external opening nor setal appendage on the cuticula connected with these cells, they are hardly believed to be sense cells. At the distal end of the fifth tarsal segment, a layer of hypodermal cells runs toward the unguitractoral tendon forming a cone-shaped structure that embraces the tendon (Figs. 48 and 62, HP<sub>2</sub>).

*Basement membrane* (Figs. 48 and 56, BM)—The basement membrane is very distinct and closely adherent to the hypodermis. It is thin and bright in the preparations.

*Connective tissue* (Figs. 57, 61, and 62, CN)—In a cross section of the tarsal segment, the connective tissue is seen to run transversely from each side of the segment to form a septum which divides the segment into two hemispherical chambers. In the dorsal chamber, the tarsal nerves and the trachea are located, while in the ventral chamber, only the unguitractoral tendon is present. The size of the blood cells is distinctly larger in the dorsal chamber.

*Unguitractoral tendon* (Figs. 51 and 56-61, UT)—A tendon arises from the unguitractoral plate and extends throughout the five tarsal segments. The structure of this tendon is curious. It is a hollow tube surrounded by a layer of large cells each with a remarkable nucleus. In the first tarsal segment the cells are present on all sides of the tendon (Figs. 52, 53, 56, and 57, UT), while in the remaining tarsal segments, the supporting cells are present only on one-half of the surface of the tendon, leaving the other half naked. The supporting cells are present either on the dorsal side or on the ventral side and this condition seems to alternate in the tarsal segments from the second to the fifth. In other words, in the second segment, the supporting cells are present on the ventral side of tendon (Fig. 58, UT), in the third segment, they are



present on the dorsal side (Figs. 54 and 59, UT), in the fourth segment they are present on the ventral side and in the fifth segment they are present on the dorsal side again (Figs. 55 and 61, UT).

*Trachea* (Figs. 51 and 56, TR)—A main trachea runs throughout the five tarsal segments with three branches in the first tarsal segment (Fig. 57, TR). The trachea and also its branches lie in or near the septum of connective tissue (Fig. 61, TR). Intima and taenidia are distinct.

Two tracheal glands similar to that found in the housefly are found in the first tarsal segment; each is connected with the tracheal wall. They are located near the proximal end and the distal end of the segment (Fig. 51, TG).

*Nerves* (Figs. 49, 50, and 51, NV)—A pair of nerves run along the side of the hypodermis throughout the five tarsal segments. One of them is associated closely with the trachea. A thin layer of nucleated neurolemma is distinct (Fig. 50, NL).

*Sense organs*—Pringle (1938) found campaniform sensilla present on the tarsus of American cockroach. These he believes respond to strains in the cuticle and react to contact pressure in the tarsus. In the German cockroach there has not been found either the campaniform sensilla, the chemoreceptive sensilla, or even the tactile sensilla.

*Cuticular appendages*—Two types of appendages are present on the cuticula; one is the large stout spine and another is the seta. The spines are mostly present on the distal end of each segment (Figs. 46 and 51, S), while the setae are located over the entire surface of each segment (Figs. 46, 47, and 56, ST).

*Pretarsus*—The pretarsus consists of an unguitractoral plate, a single pulvillus, and a pair of claws.

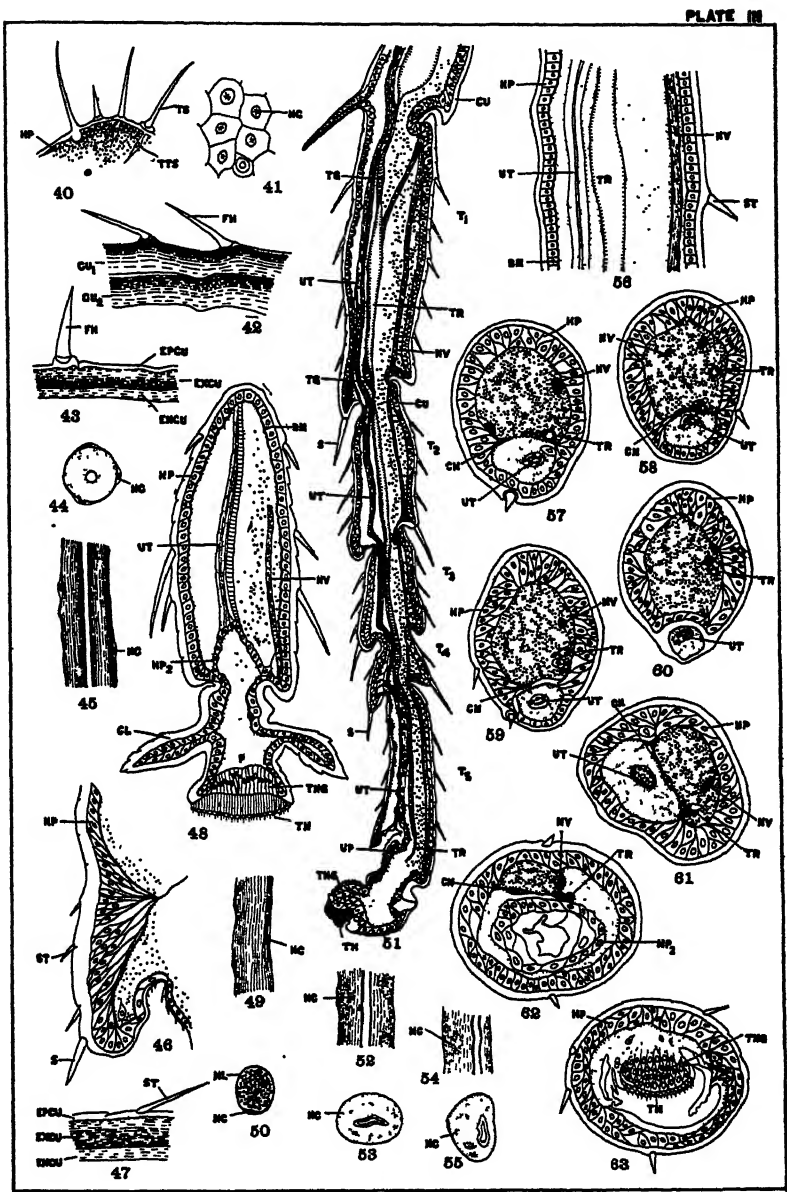
a. *Unguitractoral plate* (Fig. 51, UP)—The unguitractoral plate is located on the distal end of the fifth tarsal segment. It has very fine ridges on the ventral side. The internal cavity of the plate is fully filled with cells.

#### EXPLANATION OF PLATE III

Fig. 40. Section of tactile sensilla and setae. 41. Surface view of hypodermal cells. 42. Section showing layers of cuticula during the molting stage. 43. Section of cuticula not in molting stage. 44. Cross section of unguitractoral tendon. 45. Longitudinal section of unguitractoral tendon.

#### German cockroach, *Blattella germanica* L.

Fig. 46. Longitudinal section of the distal end of the fourth tarsal segment. 47. Section of cuticula. 48. Frontal section of the fifth tarsal segment and pretarsus. 49. Longitudinal section of tarsal nerve. 50. Cross section of tarsal nerve. 51. Sagittal section of the entire tarsus. 52. Longitudinal section of unguitractoral tendon in first tarsal segment. 53. Cross section of unguitractoral tendon in the first tarsal segment. 54. Longitudinal section of the unguitractoral tendon in the third tarsal segment. 55. Cross section of the unguitractoral tendon in the fifth tarsal segment. 56. Longitudinal section of first tarsal segment. 57. Cross section of first tarsal segment. 58. Cross section of second tarsal segment. 59. Cross section of the third tarsal segment. 60. Cross section of the fourth tarsal segment. 61. Cross section of the fifth tarsal segment showing the trachea lying in the connective tissue. 62. Cross section of the distal portion of the fifth tarsal segment. 63. Cross section of the distal end of the fifth tarsal segment, including a part of the pretarsus.



b. *Pulvillus* (Fig. 48, P)—The pulvillus is a bell-shaped membranous structure with numerous tenent hairs on its surface (Figs. 48, 51, and 63, TH). The distal end of the pulvillus is invaginated and forms two folds at the tip. A layer of gland cells comprising the tenent gland (Fig. 48, TNG) is present at the distal margin and a layer of hypodermal cells runs along the lateral margins. Nerve cells are present in the cavity.

c. *Claws* (Fig. 48, CL)—The claws are hollow structures containing a layer of hypodermal cells.

#### DISCUSSION OF THE HISTOLOGICAL DIFFERENCES AMONG THOSE INSECTS STUDIED IN RELATION TO THE RESPONSES OF DDT

In comparing the histological structures of the tarsi of those insects that have been studied, two aspects are deemed important in relation to the responses of these insects to DDT. One is the thickness of the exoskeleton and another is the presence or absence of the chemoreceptive organs in the tarsi. For analyzing these two factors, a tabulation (Table I) is given to show their interrelations.

TABLE I  
A COMPARISON OF THE THICKNESS OF THE EXOSKELETON, CHEMORECEPTIVE ORGANS AND MORTALITY

Species	Thickness of Exoskeleton	Chemoreceptive Organ	Mortality to DDT
Housefly.....	12.5-25 microns	present	high
Mexican bean beetle.....	25-45 microns	absent	low
Mexican bean beetle larva	15-40 microns	absent	low
German cockroach.....	60-90 microns	absent	low

There is no attempt to conclude here that the responses of these insects to DDT are merely because of the presence or absence of chemoreceptive organs or the thickness of the exoskeleton of the tarsi. However, the housefly which has the chemoreceptive organs in the tarsi, is more susceptible to DDT, and on the other hand, those insects such as the German cockroach and the Mexican bean beetle, both adult and larva, which have no chemoreceptive organs in the tarsi, are less susceptible to DDT. In order to conclude that the chemoreceptive organs and the thickness of the exoskeleton are the two most important factors in relation to the responses to DDT, a lot of experimental work is needed.

#### SUMMARY

1. An histological study was made of the tarsi of three species of insects which included the adult housefly, *Musca domestica* L., the adult German cockroach, *Blattella germanica* L., and both the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Huls.

2. The histology of the tarsi of three different species of insects was studied in detail. The main structures are the cuticula, hypodermis

and basement membrane which form the wall, while the trachea, an unguitractoral tendon and a pair of nerves occur within and run throughout the tarsal segments. On the cuticula there are several kinds of appendages, such as the spines, fixed hairs, tactile setae, tenent hairs and chemoreceptive setae.

3. Among the three species studied, the chemoreceptive sensilla were found only in the tarsi of the housefly. They are located latero-ventrad on the second to fifth tarsal segments and have not been found either on the dorsal side of those segments or in the first tarsal segment. The chemoreceptive organ is composed of a group of sense cells located in a subepidermal position and covered by a nucleated neurolemma continuous with that of the longitudinal nerve. The individual cells are more or less spindle-shaped. The distal end of the sensilla is attached to a long, thin-walled chemoreceptive seta.

4. The thickness of the cuticula has been measured; that of the housefly is 12.5 to 25 microns, the Mexican bean beetle is 25 to 45 microns, the Mexican bean beetle larva is 15 to 40 microns, and the German cockroach is 60 to 90 microns. In general, it may be said that the DDT susceptible housefly has a thinner cuticula than the other non-susceptible species.

#### ABBREVIATIONS

BM.....Basement membrane.	NL.....Neurolemma.
CHS.....Chemoreceptive sensilla.	NV.....Nerve.
CHT.....Chemoreceptive seta.	P.....Pulvillus.
CL.....Claw.	PL.....Planta.
CN.....Connective tissue.	PT.....Pretarsus.
CU.....Cuticula.	S.....Spine.
CU <sub>1</sub> .....Old cuticula.	ST.....Seta.
CU <sub>2</sub> .....New cuticula.	T.....Tarsus.
E.....Empodium.	T <sub>1</sub> .....First tarsal segment.
ENCU.....Endocuticula.	T <sub>2</sub> .....Second tarsal segment.
EPCU.....Epicuticula.	T <sub>3</sub> .....Third tarsal segment.
EXCU.....Exocuticula.	T <sub>4</sub> .....Fourth tarsal segment.
FH.....Fixed hair.	T <sub>5</sub> .....Fifth tarsal segment.
G.....Gland.	TG.....Tracheal gland.
HP.....Hypodermis.	TNG.....Tenent gland.
HP <sub>1</sub> .....Two layers of hypodermal cells.	TH.....Tenent hair.
HP <sub>2</sub> .....Hypodermal cells invaginated into the distal end of the fifth tarsal segment.	TR.....Trachea.
NC.....Nucleus.	TS.....Tactile seta.
	TTS.....Tactile sensillum.
	UP.....Unguitractoral plate.
	UT.....Unguitractoral tendon.

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AN INSECT BOOK FOR THE POCKET, by EDMUND SANDARS. 349 pages, 36 colored plates, numerous text figures. Geoffrey Cumberlege, Oxford University Press, London, 1946.

As might be supposed, this small volume deals especially with insects of the British Isles and is a general treatment which contributes far more to the development of broad knowledge of insects and other Arthropoda than to acquaintance with the many species. It should be exceedingly valuable to the nature lover who seeks to know this vast division of the animal kingdom but is content to recognize bees and wasps and other forms and to know something of their lives without being concerned with the identification of species.

The amount of information included is astonishing in so small a book, but the 400-word pages, attained by the limitation of margins with no loss of legibility, and the reduction of type size in the routine treatment of morphological data and life cycles still further contributes to the making of a volume of considerable actual size within dimensions small enough for the pocket.

The text is very well written. It is somewhat surprising to find ordinary words such as foot and toe mingled with the special terms of entomology, but the author is meticulous in making his meaning clear and he attains a fresh and readable style by his method. He has met the difficult task of presenting an exceedingly complex group to the uninformed with admirable success. Indeed, when one considers that this is a Comstock or an Imms or even a Schröder boiled down to a companion on rambles afield, the result is quite astonishing.

The book concludes with a brief bibliography and an index. Unfortunately the price has been clipped from the jacket of the review copy and therefore cannot be quoted, for, in spite of emphasis on the British fauna, the book should be both interesting and informative to beginners in entomology, either young or old, wherever they may live.—A. W. L.

# A SEROLOGICAL STUDY OF SOME ORTHOPTERA

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Many different classifications have been devised relating insects, chiefly on the basis of their morphology. In their broader outlines these classifications show general agreement. When the systematic relations of orders to each other, and the relations of different genera within an order are in question, almost as many arrangements can be found as there are authors on the subject. Whenever there is an uncertainty in the relations of these groups, a classification showing these of necessity express the views of the individual who devised it. Some taxonomists (Blatchley 1920) have expressed the opinion that one order could follow another in almost any sequence without serious loss to the expression of their systematic relationships. Fernald (1921), however, cited the need for a reliable, objective method in determining insect relationships.

Granted that the antigenic constitution of organisms is a part of their essential nature, then the technique of precipitin testing should make it possible to conduct an objective, and quantitative analysis of the systematic relationships of insects or any other kinds of organisms. The interfacial or ring test as described by Boyden (1926) has proven itself to be of considerable value in serological studies. An improvement in technique has been made by the use of photoelectric measurements of the turbidities developed in precipitin reactions. The Libby photorefractometer (1938) appears to be an instrument by which species, and sometimes types within a species, might easily and consistently be distinguished, (Boyden and DeFalco 1943).

Serological methods present a new basis for systematic studies by concerning themselves with the analysis of similarities and dissimilarities in the antigenic constitution of different organisms. Biochemical investigations of the serologically active chemical constituents of the body may be the most objective methods possible for dealing with the essential natures of these organisms.

Erhardt (1929) presents a review of early investigations conducted on the serological classification of insects. Experiments by Brown and Heffron (1928), Martin and Cotner (1934), and Cumley (1940) have shown high correlation between the precipitin reactions of extracts of insect bodies and their present systematic positions.

This paper extends the studies in the systematic serology of insects and deals principally with the family Blattellidae (Roaches) of the order Orthoptera. Certain other insects in the same order are used also to introduce interfamilial relationships. An attempt is made to consider some of the principal objections to the use of this biochemical method in systematic studies.

## MATERIALS AND METHODS

Antigen extracts were prepared from each of the species listed below. Identifications of the forms used were checked against Blatchley (1920).

## Order ORTHOPTERA

COMMON NAME	SCIENTIFIC NAME	KEY
1. American roach.....	<i>Periplaneta americana</i> (Linn.).....	CA and CAA
2. Surinam roach.....	<i>Pycnoscelus surinamensis</i> (Linn.).....	CAu
3. German roach or Croton Bug..	<i>Blatella germanica</i> (Linn.).....	CG and CGG
4. Oriental roach.....	<i>Blatta orientalis</i> Linn.....	CO
5. Tropical roach.....	<i>Leucophaea maderae</i> Fabr.....	CL
6. Broad Wood-roach.....	<i>Parcoblatta lata</i> (Brunn).....	CBb
7. Florida lubber grasshopper...	<i>Romalea microptera</i> (Beauv.).....	GLu
8. Red-legged grasshopper.....	<i>Melanoplus femur-rubrum</i> (DeG.).....	GRI
9. Straight-lanced grasshopper..	<i>Conocephalus strictus</i> (Scudd.).....	S2
10. Chinese mantis.....	<i>Paratenodera sinensis</i> (Sauss.).....	PM
11. Common field cricket.....	<i>Gryllus assimilis</i> .....	KC

Insects used in the tests were gathered in the field or secured from sources recommended by the Rutgers University Department of Entomology.

## PREPARATION OF ANTIGENS

All the antigens used in these experiments were prepared directly from fresh material. The insects were gathered in the field, or secured from other sources, brought into the laboratory and starved for forty-eight hours. This was done to help in the removal of any soluble proteins from the digestive tracts which might later influence some of the cross reactions.

In preparation of the saline extraction, the wings were removed as were the tibia and tarsi of the legs, just before grinding, since these parts are composed chiefly of chitin and would only interfere in the grinding operation. When only a small number of individuals was available the insects were ground in sand with mortar and pestle. When large numbers of organisms were used, as was the case with the roaches, the entire insect collection was first macerated and crushed with an ordinary hand-operated meat grinder and then ground with mortar and pestle. During both types of preparations 0.85 per cent buffered saline (ph 7) was added to prevent the drying and denaturation of soluble fractions. No attempt was made to add a constant amount of saline per unit weight of organisms since the extracts were later standardized in terms of protein nitrogen (Table I). When only a small number of organisms was available, a relatively larger amount of saline had to be added in order to provide volumes of extracts large enough to conduct the projected experiments.

The saline-insect mixtures were shaken steadily by machine for fifteen minutes and then placed in the refrigerator at  $3 \pm 1^\circ$  C. for twenty-four hours. At this time the extraction mass was shaken again for five minutes and returned to the cold chamber. Approximately twenty-

four hours later the extraction mass was clarified by the following processes:

- (1) Pressed through fine bolting cloth to remove chitinous and other heavy particles.
- (2) Centrifuged for one hour at 2500 r.p.m.
- (3) The milky supernatant liquid was decanted off and centrifuged again for one hour at the same speed.
- (4) The supernatant liquid then was given a nonsterile preliminary filtration through a Seitz filter, changing pads as often as necessary.
- (5) A final sterile filtration through the Seitz filter was performed. The sterile extract was bottled in serum vials and stored in the refrigerator until used. In no case was a preservative used with these antigen solutions.

TABLE I  
PROTEIN NITROGEN IN EXTRACTS OF VARIOUS ORTHOPTERA

Organism	Key	Protein in Grams/10 cc.
1. American roach.....	CA1	0.82
2. American roach.....	CAA1	0.70
3. Surinan roach.....	CAul	0.09
4. German roach.....	CG1	0.77
5. German roach.....	CGG1	0.52
6. Oriental roach.....	CO1	0.92
7. Tropical roach.....	CL1	0.69
8. Broad Wood-roach.....	CBb1	0.06
9. Florida lubber grasshopper.....	GLu	0.08
10. Red-legged grasshopper.....	GR11	0.32
11. Straight-lanced grasshopper.....	S2	0.04
12. Chinese mantis.....	PM1	0.12
13. Field cricket.....	KC1	0.13

#### PREPARATION OF ANTISERA

The immune sera were produced in rabbits, injected intravenously. Five milligrams of protein per kilogram body weight of rabbit was given in the first injection. Three more injections were given on alternate days, the quantity of material injected being doubled with each successive dose.

The rabbits were trial-bled seven days after the last injection. If the antisera were potent enough, final bleeding was accomplished on the eighth day. For the final bleeding, the blood was drawn directly from the heart of the anaesthetized rabbit. The blood so obtained was permitted to clot. After from seven to fourteen hours the clear serum was decanted off and centrifuged. The antiserum was sterilized by filtration in a Seitz filter; bottled in 5 cc. serum vials; and stored in the refrigerator until needed.



## PREPARATION OF SPECIAL ANTIGENS AND ANTISERA

To determine the effects of lipoidal materials on insect precipitin reactions preparation of the antigens was altered. The macerated insects were expressed through fine bolting cloth to remove the chitin and then immediately lyophilized using the Florsduff-Mudd procedure (1935). The lyophilized material was then divided into two portions.

One portion was extracted with 0.85 per cent buffered saline using the proportion of 100 cc. of saline for  $2\frac{1}{2}$  grams of lyophilized roach. The saline-roach mixture was shaken for one hour, placed in the refrigerator overnight, shaken for thirty minutes more, and then centrifuged at 2500 r.p.m. for one hour. A portion of the slightly cloudy supernatant liquid was decanted and used as an antigen. The remaining supernatant liquid was cleared by sterile filtration through a Seitz filter. The sterile filtrate was bottled, under sterile conditions, in serum vials, and stored in the refrigerator. The antigen suspension was injected intravenously in the rabbit beginning with  $\frac{1}{2}$  cc. and using doubling doses on alternate days for four injections. Trial bleedings were performed seven days after the last injection. Final bleeding was accomplished on the eighth day, if the precipitin test titers were significant.

The second portion of the lyophilized material was extracted first to remove the lipids, using a modification of the Bloor (1928) technique. Absolute ethyl ether and absolute ethyl alcohol in the proportions of 3 : 1, were mixed into a solution, 100 cc. of which was used for each gram of lyophilized roach being treated. The Bloor's-roach mixture was shaken for one hour and placed in the refrigerator overnight. On the next day, the Bloor's solution was pipetted off, replaced with fresh Bloor's solution, and shaken again for one hour. This procedure was repeated once more. The lipid extracted roach material was filtered, dried at room temperature for 24 hours, and then extracted with saline and injected intravenously as described above.

## TESTING OF ANTIGENS AND ANTISERA

Precipitin tests were made in two ways: (1) titrations were performed using the ring test technique (Boyden, 1926), and (2) measurements based on the turbidities of the reactions were taken by use of the Libby photronreflectometer (1938).

The photron'er (photronreflectometer) method was used essentially as outlined by Boyden and DeFalco (1943). One chief departure should be noted. If dilutions covering the entire range of reactivity between antigen and antibody are made, then the absolute antigen concentration in the initial dilution cell need not be considered. Subsequent dilutions of the antigen concentration must be made in a uniform manner, however. In these experiments each cell had an antigen concentration one-half that of the preceding cell in the dilution series. The respective volumes of antigen dilution and antisera contained in each cell were always kept constant; namely, 1.7 cc. of antigen dilution and 0.3 cc. of antiserum. The insect antigens were in most cases so weak that the undiluted antigens when reacted with undiluted antisera gave photron'er readings past the zone of maximum turbidity in the region of

antibody excess. The result was that under these conditions only a part of the curve of reaction could be obtained. In order to obtain a complete curve from zero in the antigen excess zone to zero in the antibody excess zone it became necessary to dilute the antiserum by an appropriate factor. Dilutions of one part antiserum to one part saline,

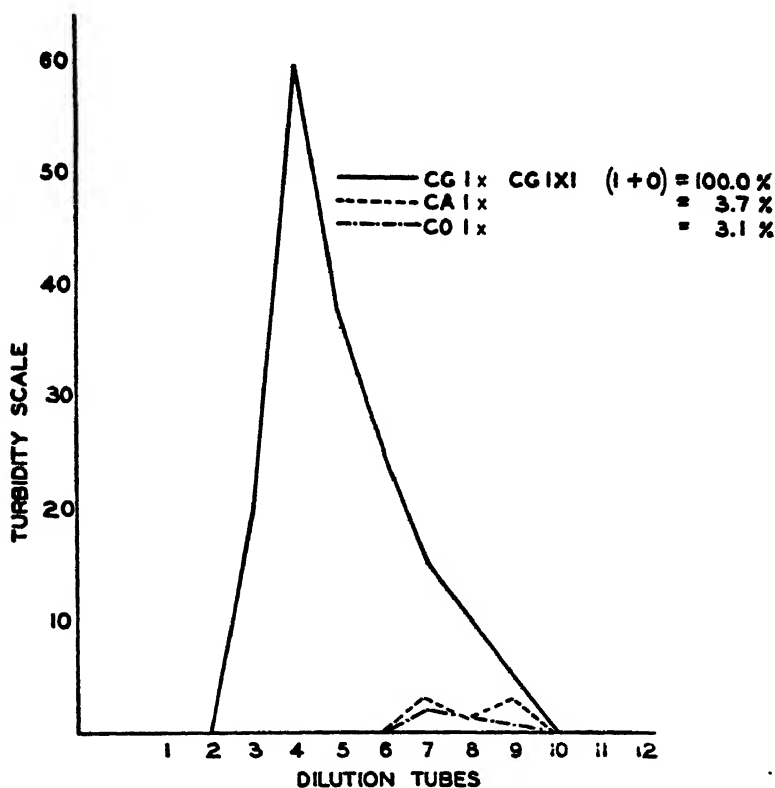


FIG. 1. A highly specific titration curve. The narrow width and sharpness of the anti-German roach serum (CG 1 X 1) curve when tested with its homologous German roach antigen, *Blatella germanica*, CG1, is indicative of a single antigen-antibody system. The heterologous reactions with other roaches, *Periplaneta americana* (American roach) CA1, and *Blatta orientalis* (Oriental roach) CO1, were barely significant.

or one part antiserum to two parts saline were sufficient in all cases to give complete curves.

With the ring test, standardization of the initial dilution tube is essential for comparable results. The ratio of one part protein (as established by the Kjeldahl nitrogen determinations) to five hundred parts saline (1 : 500) was chosen for the first dilution tube. All subsequent dilutions were made as reported by Boyden and Noble (1933).

Clear, freshly prepared, antigens and antisera were used to perform the precipitin tests included in this paper.

From his experience the author feels the need of emphasizing certain points regarding the ring test method:

1. The exact protein concentration should be known in all antigen solutions in order for the reaction titers to be comparable.
2. Absolutely clear antigens must be used in every test. Very fine rings are easily lost in cloudy solutions.

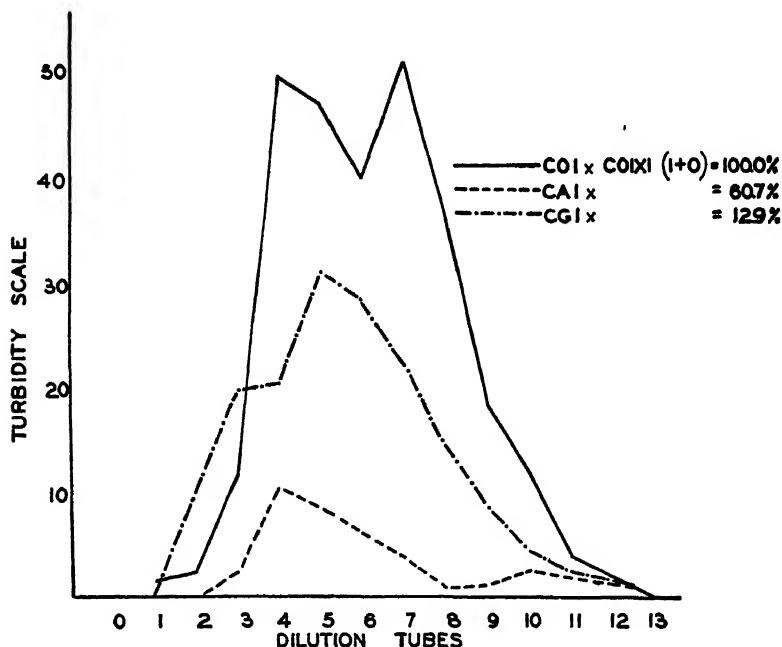


FIG. 2. The anti-Oriental roach serum (CO 1 X 1) showed the ability to distinguish other roach organisms, CA 1 (American roach) and CG 1 (German roach). The percentage values are indicative of the degree of correspondence between the roach antigens.

3. The layering of the antisera must be done with extreme care to obtain a sharp interfacial division.

4. Jarring the tubes must be avoided. Fine rings easily become diffuse and are lost because of this carelessness.

#### EXPERIMENTAL RESULTS

##### *Relationships*

Immune sera produced against members of the family Blattidae (The Roaches or Cockroaches) proved in every case, to be highly differentiating when used against members of that family. Each antigen induced the formation of a powerful antiserum. Reciprocal tests were

conducted and in no instance was there any variation in the order of relationship which these roaches showed to each other.

A study of figures 1, 2, and 3 indicates that the Oriental roach, *Blatta orientalis*, and the American roach, *Periplaneta americana*, are

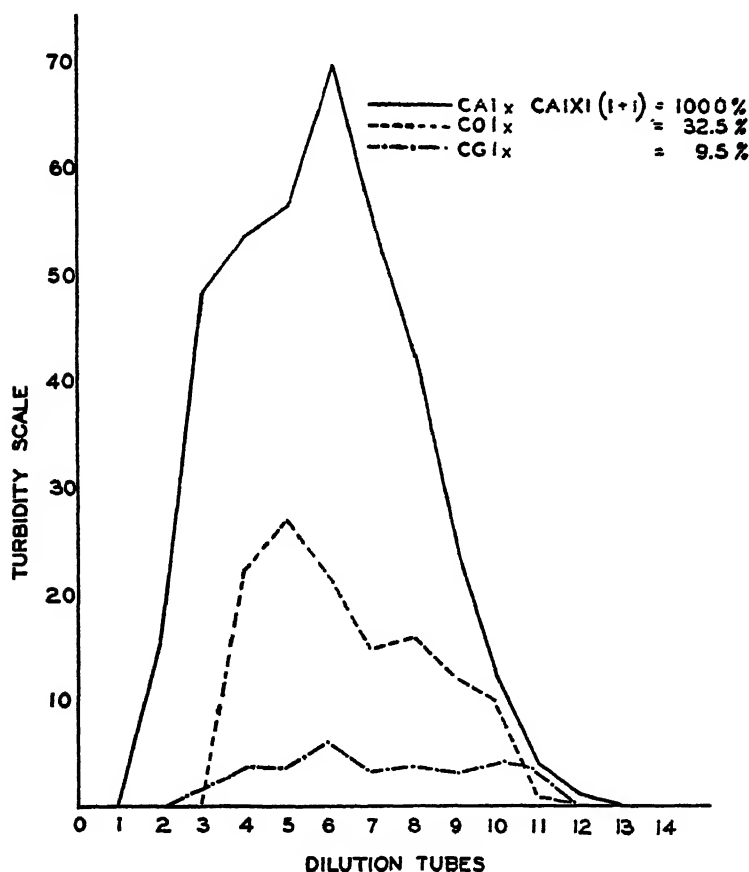


FIG. 3. These curves are the reciprocals of the tests in Figure 2. The percentage values between the American roach (CA 1) and the Oriental roach (CO 1) show a reduced correspondence. It will be noted, however, that the antiserum CA 1 X 1 against the American roach has been diluted with an equal part of saline. This treatment of the antiserum increases its specificity (Boyden and DeFalco, 1943) and the reduced activity is in accord with this principle.

more closely related to each other than to the German roach, *Blatella germanica*. The antiserum against the German roach was highly specific giving heterologous curves which were barely significant; a differentiation between the Oriental and American roaches using this antiserum was not possible. The anti-American and anti-Oriental

roach sera, however, were able to select out the German roach antigen with approximately equal sensitivity.

A second antiserum produced in response to an American roach antigen was less specific than the first antiserum and gave to the German roach antigen a heterologous reaction value of 51% (figure 4), as contrasted to the original value of 9.5% (figure 3). This behavior is not inconsistent with known facts concerning the reaction of different rabbits to the same antigen, all other factors remaining constant.

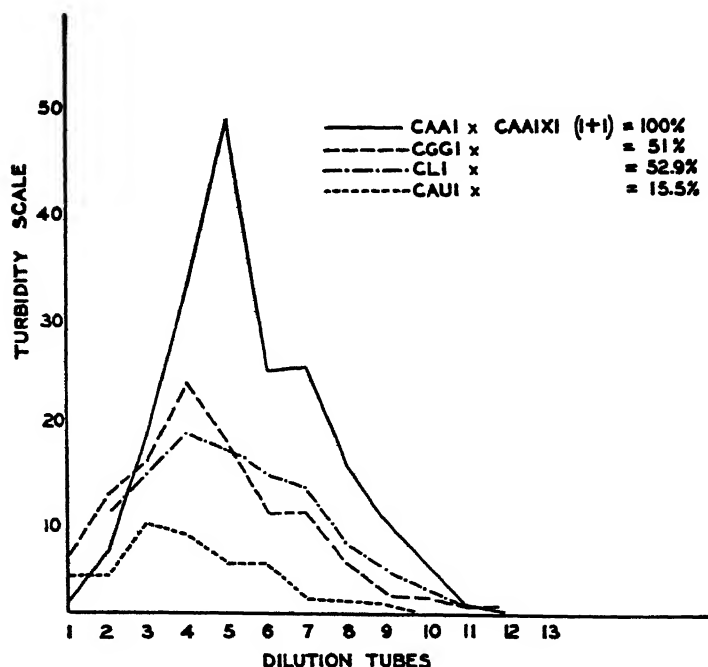


FIG. 4. The Tropical roach (CL 1) is about an equal distance from the American roach (CAA 1) as is the German roach (CGG 1). The percentage value between the American and German roaches serves to demonstrate the variability in rabbit response; compare with value given in Figure 3. CAU 1 is the Surinam roach.

The Tropical roach, *Leucophaea maderae*, shows approximately the same degree of reactivity to the American roach antiserum as does the German roach antigen (figure 4). The Surinam roach, *Pycnoscelus surinamensis*, is the most distant species to the American roach, of the forms tested.

The order of relationship established by the anti-German roach serum in figure 5, serves to demonstrate constancy of behavior found to be characteristic for all the extracted antigens. In these curves the American and Tropical roach exhibit approximately the same degree of

reactivity toward the German roach. As before, the Surinam roach is the least reactive of the roach species tested.

By comparing values in figures 6 and 7 it can be seen that the order of magnitude for the heterologous reactions is about the same. The

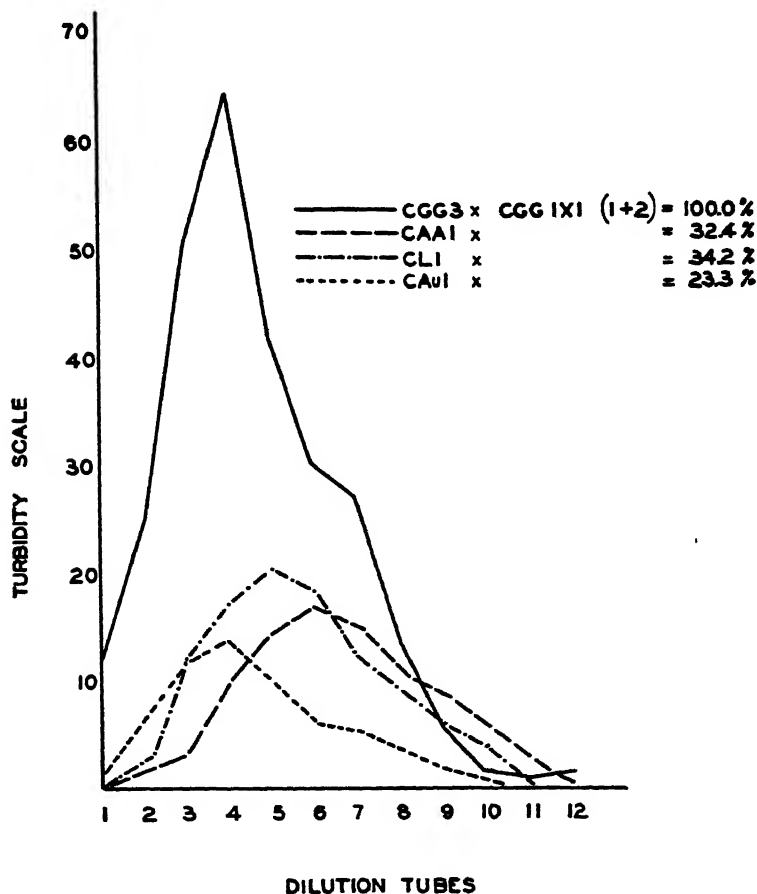


FIG. 5. The Surinam roach (CAu 1) is less reactive in the above graph and in Figure 4, than is the Tropical roach (CL 1). This constancy of behavior establishes the Surinam roach as more distant from the American and German roaches than is the Tropical roach.

Tropical roach and the Surinam roach show closer relationship to each other than the German or American roaches demonstrate to either one of them. It appears also that the German roach is slightly more closely related to the Tropical and Surinam species than is the American roach.

Intra-family relationships using the ring test or interfacial technique (figures 8, 9, 10 and 11) could only be established by diluting the

roach antisera with one or two parts saline, as indicated. By this means it was possible to reduce the relative concentrations of the reactants sufficiently to establish heterologous reactions whose titers did not equal that of the homologous reaction, as was the case when undiluted, or more concentrated antisera were employed. Even after the reduced heterologous titers were obtained, only the more closely related

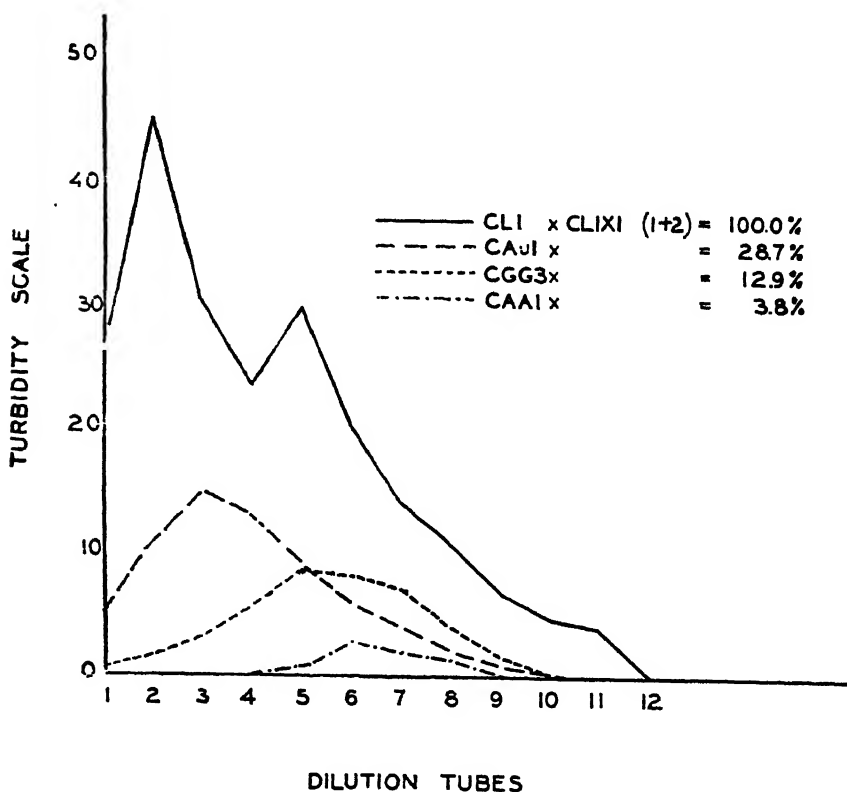


FIG. 6. The Tropical roach (CL 1) when reacted with its homologous antiserum shows a distinct bimodal curve. Only one other roach antigen and antiserum (Figure 2) demonstrated this characteristic. These curves indicate the presence of more than one kind antigen and probably more than one kind of antibody in the reaction.

species were selected out with a certainty. Other roach species were lumped together. One inconsistency in already established serological relationships would, at first glance, appear to exist in figure 9, where the Tropical roach exhibits a closer relationship to the German roach than does the American roach. DeFalco (1942) demonstrated how such a situation could arise when mixed antigens were used in performing ring test titrations. The existence of more than one antigenic substance in

the Tropical roach antigen solution is evident from the bimodal nature of a photron'er plot of the antigen, when titrated against its homologous antiserum (figure 6). It should be remembered that the titer of the ring test is the highest dilution of antigen at which a reaction between it and an antiserum of a given strength can be detected with the naked eye, and that this dilution is used in most comparative serology studies. At best the ring test titer presents but a single point on a whole dilution series and hence, cannot be regarded as a true index of the similarity between antigens being compared. The entire reaction curve of antigens and antisera must be plotted if more critical analyses of animal relationships using serological methods are to be obtained.

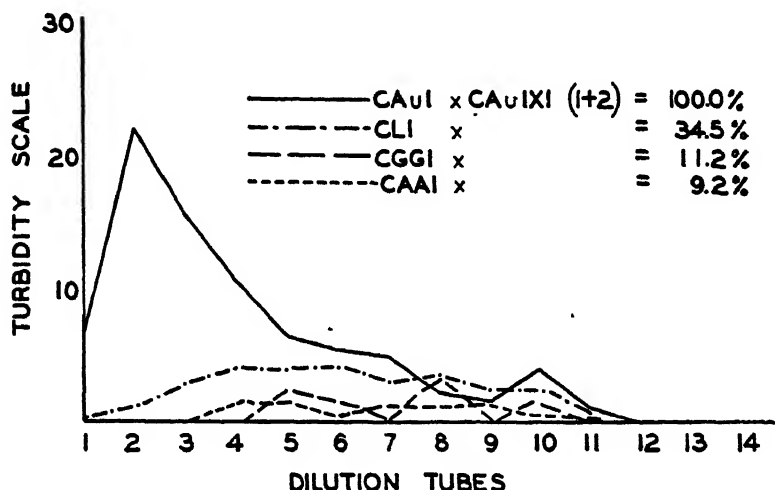
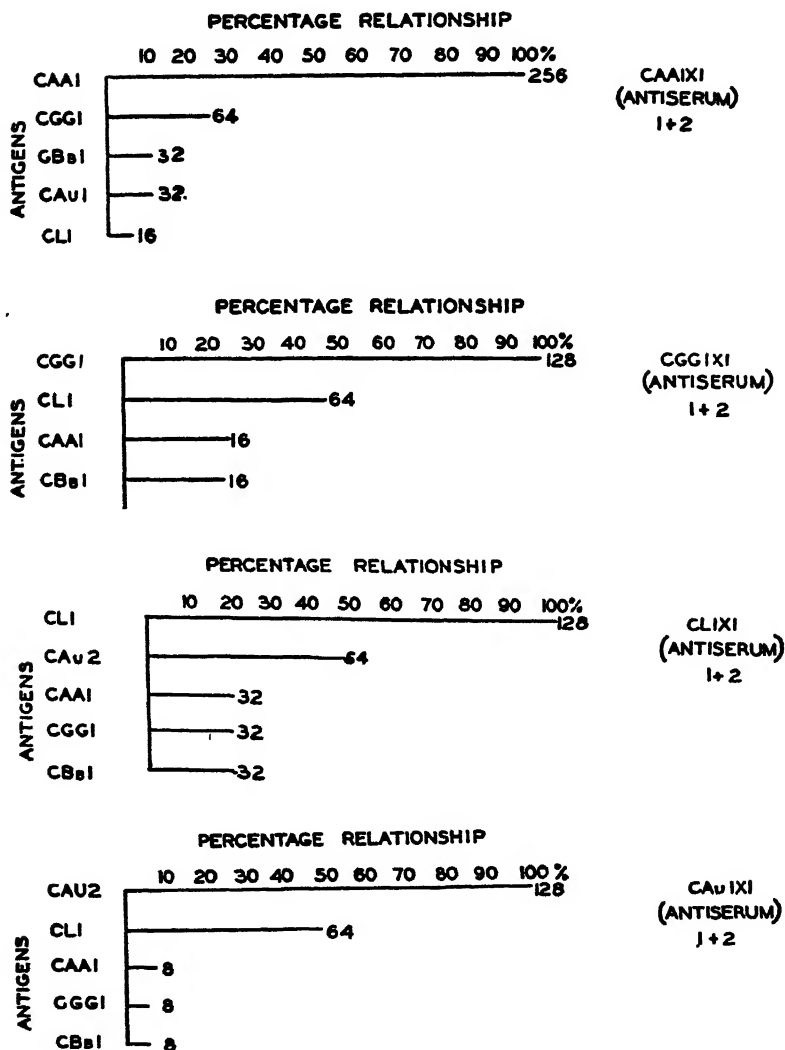


FIG. 7. The rarer forms, the Tropical roach (CL 1) and the Surinam roach (CAu 1) show a very definite and consistent (Figure 6) order of relationship with the more common forms. The American roach (CAA 1) is more distant from the Tropical and Surinam roaches than is the German roach (CGG L).

Once the limitations of the ring test are understood, it can be an effective serological tool in certain cases. Inter-family tests, for example, were undemonstrable using the photron'er with the antisera available (figure 12). Using the ring test technique, however, it was possible with undiluted antiserum, to obtain reactions to four different families in the insect order Orthoptera (figure 13). Of these, the Gryllidae (Crickets), and the Tettigonidae (Katydids) appear to be more closely related to the Blattidae (Roaches), than do the Acrididae (Locusts) and the Mantidae (Mantids). In a subsequent paper reciprocal tests will be described which establish more definitely these inter-family relationships. Classifications based on reactions related to a single locus, and on ring test results alone can lead to erroneous conclusions.





FIGURES 8, 9, 10, and 11. These charts are ring test reactions giving the degree of relationship between the various species of roaches in the family Blattidae. The lines show the percentage relationship between the specimens considered. The number following each line represents the titer of the reaction in thousands. For example, the number 64 represents one part antigen in 64000 parts of saline. Antisera were diluted with one or two parts saline, as indicated, to increase the specificity of the reactions.

#### KEY

- CAA 1—American roach (*Periplaneta americana*).
- CGG 1—German roach (*Blattella germanica*).
- CL 1 —Tropical roach (*Leucophaea maderae*).
- CAU 1 or
- CAu 2 —Surinam roach (*Pycnoscelus surinamensis*).
- CBb 1—Broad Wood-roach (*Parcoblatta lata*).

## Lipids

The significance of lipid substances in the study of insect relationships is of interest, particularly when saline extracts of the insects are used for comparative studies. In some recent work with invertebrates, as reported by Wilhelmi (1940), and by Cumley (1940), the removal of

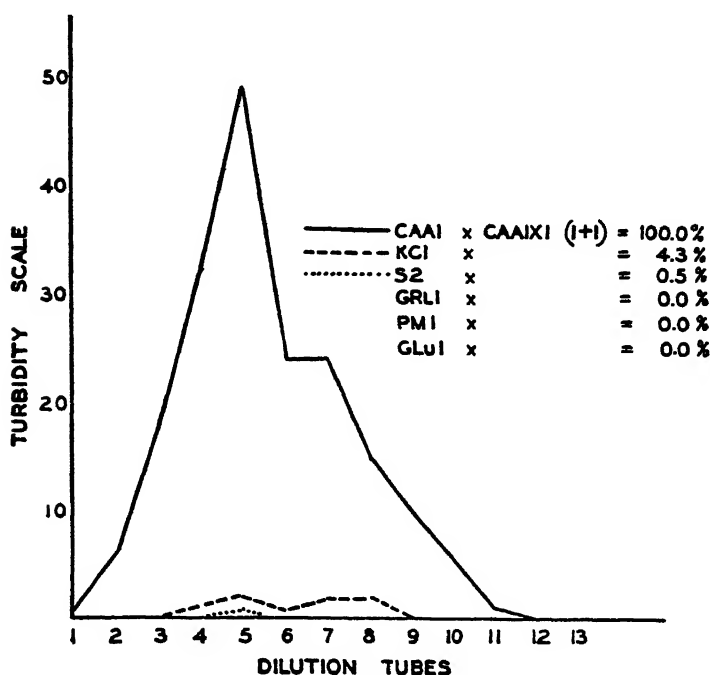


FIG. 12. Interfamily specificity is strikingly shown in this curve. Almost a complete exclusion of the other forms of Orthoptera is demonstrated. This is evidence that a wider gulf exists between families than exists between genera within a family. This is in accordance with morphological findings. The test when conducted with undiluted antisera still showed complete specificity. The homologous curve moreover was moved to the left, and only the region of antibody excess could be precipitated.

CAA 1—*Periplaneta americana* (American roach).

KC 1—*Gryllus assimilis* (Common field cricket).

S 2—*Conocephalus strichus* (Straight-lanced grasshopper).

GRI 1—*Melanoplus femur-rubrum* (Red-legged grasshopper).

PM 1—*Paratenodera sinensis* (Chinese mantis).

GLu 1—*Rhomalea microptera* (Florida lubber grasshopper).

lipid substances has yielded antigens which appear to give remarkably consistent results.

Figures 14 and 15 show a comparison between the saline extract of a lyophilized roach preparation (salex), and the saline extract of a lipid extracted, lyophilized roach preparation (lipex). The salex and lipex preparations of these German roach antigens were equal in their capacity

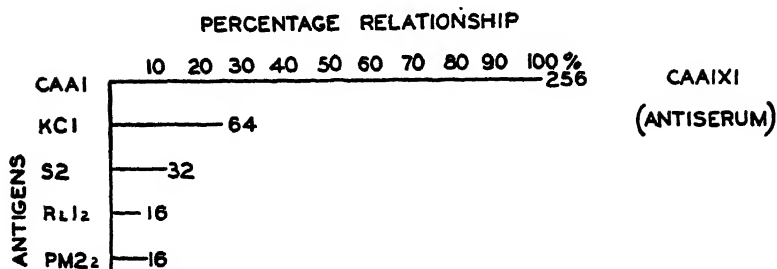


FIG. 13. Families within the order Orthoptera demonstrate different degrees of similarity to the Blattidae antigen. This chart, when compared with the same tests as performed on the photron'er (Figure 12), demonstrates the ability of the ring test to measure the titers of more distantly related forms. Dilution of the antiserum with one part saline made it completely specific.

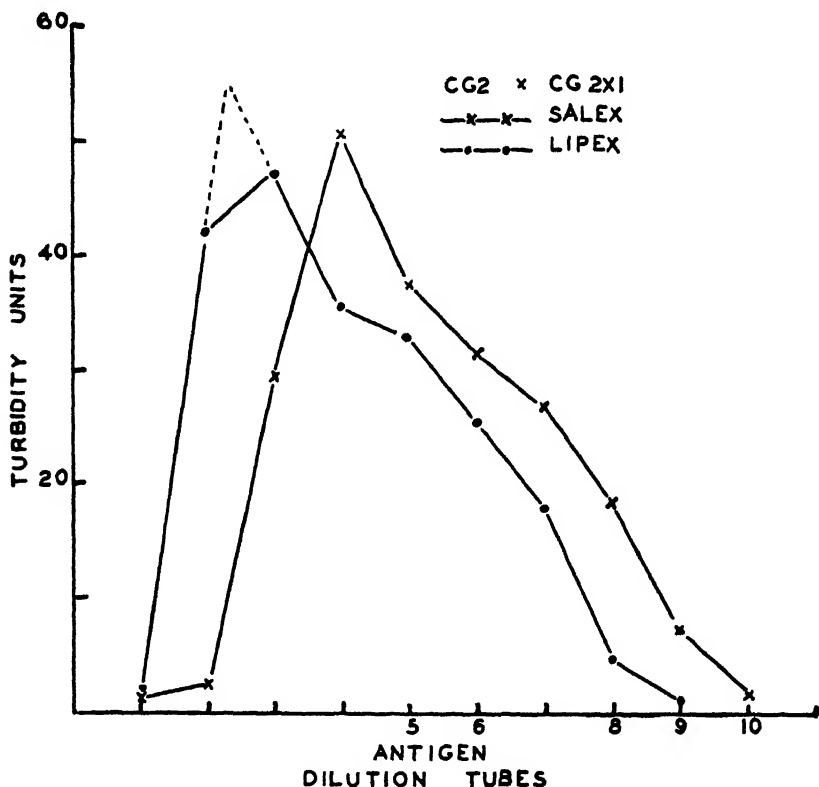


FIG. 14. The lipid-free curve (lipex) of the German cockroach (CG 2) antigen shows only a slight displacement to the left of the homologous saline extracted lyophilized roach (salex) curve. The dotted portion of the curve indicates the approximate position of the peak; it also emphasizes the essential similarity of the two curves. Both curves are of the same order of magnitude.

to react with an antiserum to either antigen. Both antisera produced against the salex and lipex antigens (German roach) were highly specific. Using the undiluted antiserum CG2X2 (German roach antilipex serum), a heterologous curve was obtained with salex and lipex preparations of the American roach. The lipex heterologous antigen showed only a slightly more amplified curve than the salex. Saless and lipex prepared antigens to the Oriental roach were also tested against the same (anti-lipex) antiserum, but did not react.

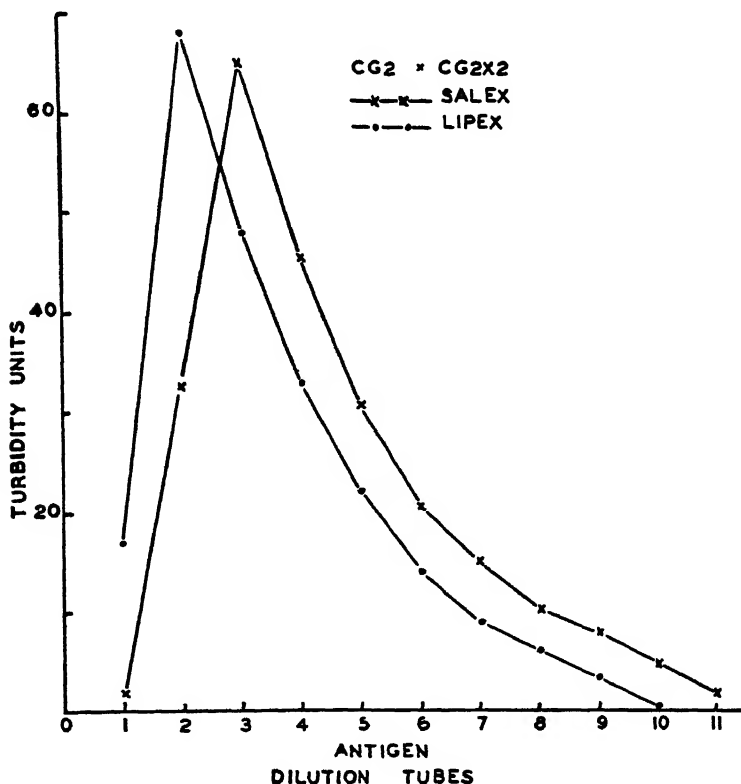


FIG. 15. The striking similarity of the homologous lipid-free antigen (lipex) and the saline antigen curves, indicates the presence of very similar antigenic substances in both extraction preparations. CG 2 are the German cockroach antigens and CG 2 X 2 the homologous antiserum made against the lipex antigen.

#### DISCUSSION OF EXPERIMENTS

A fundamental question challenging the validity of experiments using extracts from grindings of whole insects as a basis for systematic classification might rightfully be raised. It is simply this: Are the antigens prepared as described really comparable? Admittedly, comparisons using insect sera, or extracts of homologous structures or organs in the insect body would theoretically present a more critical basis for

comparison. However, the use of sera, or extracts of homologous organs are not always practical when small organisms are being considered.

As a preliminary study, antigens prepared as outlined in this paper can be regarded as comparable representatives of these species for several reasons: (1) the extraction procedure selects out only the more soluble materials, (2) the rabbit responds only to the better antigens. Differential antigenicity of proteins has been well established in other serological work. (Boyden and DeFalco 1943), (3) antibodies react specifically only with *corresponding* antigens, (4) reciprocal tests provide ample evidence for the validity of the relationships, (5) antigens prepared from different lots of the same species of insect and tested with an antiserum made against one of them gave homologous curve areas that were within the limits of error of the photometer as applied to these tests.

The insect morphologist might also raise objections to the worth of reciprocal serological tests whose degree of correspondence varies to the extent found in the data given in this paper. It is common knowledge that the greatest variable in any given serological problem is the animal that produces the antibodies. The different percentage relationships between organisms as shown by the reciprocal tests are the result primarily of the variability of rabbit response, which in turn is a function of the animal's physiological condition. Several rabbits injected with the same antigen under uniform conditions could produce antisera (1) whose titration curve areas would differ, i. e., the strength of the antiserum produced against the same amount of antigen could be different for each animal, (2) whose titration curve shapes might be different, and (3) whose degrees of specificity could differ. Moreover, these three variables might assort themselves independently with respect to the behavior characteristics of a given antiserum. In all antisera tested, however, the relative order of the positions of the species tested were constant. Further explanation of the differences in antiserum behavior will not be considered in this paper. Boyden and DeFalco (1943) have presented considerable information describing the nature of antiserum behavior in precipitin systems. The lack of exact correspondence of the reciprocal tests is not a valid reason for discrediting the use of extracts of whole organisms in establishing relationships, or for not employing serological methods to classify insects.

Occasionally two different species demonstrate the same degree of serological relationship to a third form. This definitely indicates that their relationship cannot be considered as linear. When more than three species are tested it has been shown (Boyden, 1934) that at least three dimensions are needed to assure proper interpretation. With a given organism serving as a locus all animals compared to it on the basis of their serologically active components would take positions in all dimensions of space around that locus. Thus in figure 5 the American roach (CAA1) and the Tropical roach (CL1) exhibit approximately equal serological relationships to the German roach (CGG1). It is obvious too in figure 6 that the American roach, of all the forms tested, presents the least amount of serological similarity to the Tropical roach. In order to accommodate these seemingly conflicting statements, more than a single plane of space must be considered in establishing relation-

ships. An analogy can be drawn by visualizing two cities, each equidistant from New York City, but with geographic distances between them which could be greater than, and as much as twice the distance of either one of them from New York City. In the latter instances all three cities would be in a straight line with New York City midway between the other two. The American and Tropical roaches must be oriented equidistant from the German roach locus but at the same time with a greater distance between them than between either one of them and the German roach locus.

#### SUMMARY

1. Serological comparisons of whole insect extractions were made using the "ring" or interfacial test, and the photoelectric measurement of turbidities developed in the precipitin reaction.

2. In general the relative intensities of these precipitin reactions ran parallel with the systematic position of the species compared.

3. Lipid extracted saline preparations of a lyophilized roach sample were compared with saline extracts of the same lyophilized roach materials, with no demonstrable differences being detected.

4. The validity of the use of extracts of whole organisms in establishing relationships is briefly discussed.

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## A NEW SPECIES OF TENTHREDO FROM THE APPALACHIANS<sup>1</sup>

(Hymenoptera: Tenthredinidae)

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During the summer of 1946 a new species of *Tenthredo* was obtained from two localities, separated by several hundred miles, in the Appalachian mountains that traverse Pennsylvania. Later another female and two more males were studied which had been collected in 1939 from a more distant part of the Appalachian ranges in North Carolina and Tennessee. The specimens from Ohiopyle, Pennsylvania, were captured in a patch of jewel-weed at the edge of a dense, moist woods. Since most *Tenthredo*'s are active fliers, the jewel-weed could be a "sitting" habitat and not necessarily the host in which oviposition occurs.

I wish to thank Dr. H. H. Ross for his confirmation that this species had not yet been described, for his advice, and for permitting me to use the Illinois Natural History Survey collection for reference. Also I am indebted to Dr. S. W. Frost of the Pennsylvania State College and to Dr. Marion E. Smith, of the Massachusetts Agriculture College for the loan of their material.

### *Tenthredo prosopa* new species

*Female*.—Length 13.5 mm. Color almost entirely orange-yellow with some black and cream white markings. The following areas are black: a mask-like area between the compound eyes, fig. 1, apices of the mandibular teeth, lateral margins of antennal segments 1 and 2, and all of segments 3 to 9, and a fine edge around the ovipositor sheath. Cream white are: clypeus (except extreme median basal part), labrum, bases of the mandibles, and appendages of the mouth parts. A large white spot occurs above each hind coxa and on the lateral margins of the first abdominal tergite. The following areas are pale yellow: ventral portions of the mesopecta, apices of the coxae, trochanters, and a broad median band on the ventral segments of the abdomen. Tarsal claws tipped with red.

Wings hyaline; stigma, and marginal veins orange-yellow; remainder of the veins, black.

Structure typical for the *mellina* group. Inner margins of the antennal sockets strongly upraised to give a flanged appearance, the area immediately between sunken and flat; antennae long (8.5 mm.) and slender, fig. 2; head furrows deeply impressed, ridges prominent. Head generally polished; thoracic punctures weakly defined; scutellum

<sup>1</sup>Contribution No. 272 of the Department of Entomology, the University of Illinois, and the Illinois State Natural History Survey, Urbana, Illinois.

moderately convex, fig. 5; and the median portions of the mesoepisterna drawn out into a sharp angle.

*Male*.—Length 11 mm. Structure and color similar to female with the following exceptions: Black area on the head slightly more extended, including most of the inner, upturned part of the antennal sockets and tapering posteriorly to the postocellar furrows. The orange-yellow color fades into a pale white on the cheeks at the base of the mandibles. Tegulae, antero-ventral corners of the pronotum, and most of the ventral segments of the abdomen paler than the rest of the body.

*Holotype*, female.—Ohiopyle, Pennsylvania, July 21, 1946, W. L. Brown, Jr., and Stannard. Deposited in the collection of the Illinois Natural History Survey.

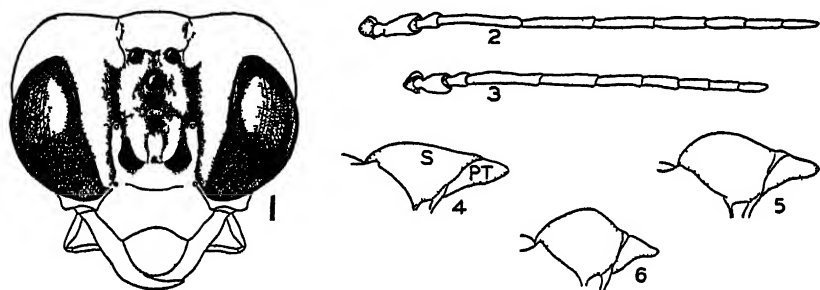


FIG. 1. *Tenthredo prosopa* n. sp. Antero-dorsal view of head.

FIG. 2. *T. prosopa*, antenna.

FIG. 3. *T. xanitha*, antenna.

FIG. 4. *T. xanitha*, scutellum and post tergite, lateral aspect.

FIG. 5. *T. prosopa*, scutellum and post tergite, lateral aspect.

FIG. 6. *T. mellina*, scutellum and post tergite, lateral aspect.  
s—scutellum. pt—post tergite.

*Allotype*, male.—Same data as for holotype.

*Paratypes*.—Andrews Bald, North Carolina, June 11, 1939, 5200 feet, C. P. Alexander, 1 ♀; Mitchell Range, Bald Knob, North Carolina, June 22, 1939, C. P. Alexander, 1 ♂; Smoky Mountains, Tennessee, 6000 feet, June 6, 1939, C. P. Alexander, 1 ♂; Black Moshannon, Pennsylvania, July 6, 1946, S. W. Frost, 1 ♂. Deposited with the holotype and in the United States National Museum, the Pennsylvania State College, and the Massachusetts Agriculture College.

The paratype female from North Carolina is smaller than the holotype, about 12 mm. in length. The black band is present between the eyes but the upper limits are less extensive and it is lacking for the most part on the area around the ocelli. Furthermore, the venter of the abdomen is mostly pale.

The male paratypes vary in size from 10 to 11 mm. with the specimens from the southern range the smaller. The black band on the head does not manifest a uniform pattern although black is always present from the antennal furrows to the inner margins of the compound eyes.



Of the specimens that are available at the present time, the individuals from the northern localities show more black coloring on the head and are of a slightly larger size than those found farther to the south.

In existing keys this species will run to *T. mellina* Norton on the basis of the yellow-orange color, the convexed scutellum, and the long slender antennae. It can be separated from *mellina* by the black area between the eyes, by the dark antennae, by the absence of a yellow orbital margin, and by the moderate convexity of the scutellum, figs. 5 and 6. In the *xantha* group, some specimens exhibit a similar orange color but it is more of a chestnut orange. *T. xantha* Norton, lacks the large black mask on the head, the antennae are shorter, fig. 3, and the scutellum is flattened, fig. 4. *T. macgillivrayi* Smulyan and *T. vittata* Kirby may approach some *xantha* variants in color but can be excluded from this group because of the pronounced black band on their hind femora.

A GENERIC AND SUBGENERIC SYNOPSIS OF THE UNITED STATES ANTS, BASED ON WORKERS, by MARION R. SMITH. American Midland Naturalist, Vol. 37, No. 3, pp. 521-627, 1947.

This synopsis includes 87 genera and subgenera, all that are known to occur in the United States. It is based on the worker caste, which has received the main emphasis in ant taxonomy. Dr. Smith has presented the generic taxonomy of the males elsewhere (1943, Amer. Midland Nat., 30: 273-321).

The treatment is as complete as anyone could wish. Besides keys, each genus and subgenus has a full description, a beautiful figure of a side view of a worker, a list of the included species and minor forms of the United States, a statement on distribution and biology, and a list of the important literature. An appendix to the paper includes a glossary of terminology and a bibliography of the ant literature for the various states.

Ant taxonomy has had the attention of a number of able men, and present knowledge of the Nearctic genera is relatively complete and sound. Dr. Smith's contribution is not in new taxonomic information and ideas, but in the careful selection and adaptation of the results of former research, seasoned with the wide and detailed knowledge of an experienced specialist. The paper is recommended as indispensable to all students of Nearctic ants and as a model for other generic revisions. We understand that separates can be purchased from the Editor of the American Midland Naturalist, University of Notre Dame, Notre Dame, Indiana.—H. TOWNES.

# A REVISION OF THE NORTH AMERICAN ANTS OF THE GENUS *MYRMICA* LATREILLE WITH A SYNOPSIS OF THE PALEARCTIC SPECIES. I.

NEAL A. WEBER

Among the best known and most interesting species of ants are those belonging to the genus *Myrmica*. Common and conspicuous insects, they have long figured in the popular literature of Europe as "red ants," or "fourmis rouges." In general habitus they may be regarded as typical ants: they are of medium size, with 12-jointed antennae (13-jointed in the male), possess a two-jointed pedicel, sharply separating the thorax and gaster, and are inconspicuously colored in various shades of blackish-, reddish- or yellowish-brown. The species are terrestrial, developing colonies of medium size, which are to be found under stones, logs or grass roots. A large part of our information on ant morphology is due to Charles Janet who, between 1892 and 1907, chose *Myrmica rubra* for many of his studies, probably because it was a typical and common ant. Wasmann and Donisthorpe have recorded 79 species of myrmecophiles occurring with ants of this genus in diverse relationships.

Students of ants dealing with a genus numerous in species and variable individuals come to think of it as being the *crux myrmecologorum*. This became my attitude while studying *Myrmica* under W. M. Wheeler in 1932-34. At that time the collection of this great master had not been divided between Harvard University and the American Museum of Natural History. In addition, the state of the world made it easy for me to acquire collections from myrmecologists in other countries and from other American institutions.<sup>1</sup> There had never been a general revision, so that collections generally consisted chiefly of unidentified specimens.

This great wealth of material, probably the largest collection of ants of this genus ever to have been brought together in one place, posed embarrassing problems. In a small collection from scattered localities it would have been relatively easy to have assigned the ants various names, using new names for specimens which differed more or less from previously recognized forms. In a very large collection, however, this is not so easy because the extremes tend to be connected by intermediate forms. It also seemed inescapable that several forms, called "varie-

<sup>1</sup>I am particularly obliged to the following for loan of material: Dr. W. M. Mann and the United States National Museum (U.S.N.M., in the locality lists); Drs. A. C. Cole, Jr., W. S. Creighton, M. R. Smith, Mary Talbot and G. C. Wheeler; Dr. H. H. Ross and the Illinois State Natural History Survey (Ill. Nat. Hist. Surv., in the locality lists); Dr. F. P. Ide and the Royal Ontario Museum of Zoology (R.O.M.Z., in the locality lists); the late Dr. E. W. Wheeler. My thanks are also due the following European myrmecologists: the late Dr. Carlo Menozzi and Mr. Bruno Finzi, of Italy; Dr. Stepan Soudek, of Czechoslovakia; Dr. H. Kutter, of Switzerland; Mr. H. K. Donisthorpe and the British Museum (Natural History); Dr. K. Fösswald, of Germany, and Dr. A. Stärcke, of Holland.

ties," which had long rested in the literature were not valid. Although these included several created by Wheeler in 1907 he concurred in my opinion. Fortunately nearly the entire type series was available in his forms and cotypes represented those described by others.

Little time could be devoted to these ants in the intervening years, but the frequent requests for identifications for use in other studies have added new records and necessitated publication of a short paper in 1939 to validate manuscript names. Also, early in 1939, copies of my keys to workers, females and males of the North American forms were distributed to Drs. A. C. Cole, W. S. Creighton, M. R. Smith, M. Talbot and G. C. Wheeler.

Since the North American *Myrmica*s are closely related to those of Europe and Asia a study of the fauna of these regions was necessary. Unfortunately Bondroit and others created numerous forms which cannot be evaluated from the descriptions alone. Emery, Wheeler and others were highly skeptical of many. In the absence of much palaearctic type material the original plan for a world revision has been abandoned. The palaearctic synopsis will assist future workers, however, in view of the 40 years which have elapsed since there has been any attempt at treating this fauna as a whole. Forel keyed the Swiss *Myrmica*s, Ruzsky the Russian forms known in 1905, Emery the palaearctic species in 1908 and Finzi the European forms in 1926. Ern. André, Stårcke and Santschi have treated parts of the European fauna. Dr. Wheeler had understandably refrained from this task for North America and had assigned it to me as my initial taxonomic problem.

#### CLASSIFICATION

In the 10th edition of the *Systema Naturae* (1758), Linnaeus gave the first name, *Formica rubra*, to a member of this genus. The generic name, from the Greek "*μυρμηξ*"—ant, dates from 1810, when Latreille made the Linnaean species the type of this genus. For the remainder of the nineteenth century *Myrmica* was made a receptacle for many species with two-jointed pedicel, which are now removed to other genera.

Since the worker is the caste usually collected, it has naturally been used as the basis of our classification. For the present treatment, especially of the North American species, I have had a sufficient number of males and females associated with the workers to be able to use the three castes together in determining relationships. The genitalia of the male have proved to be of much aid and especially the volsellae, the paired hook-like appendages on each side of the medial sagittae constituting the penis.

Every North American myrmecologist has found the workers to be highly variable. To repeat my 1939 statement: "it should be emphasized that frequently no satisfactory determination can be made of specimens unless at least the male caste is present with workers from the same nest." This variability is not unique in *Myrmica*, however, for some species of *Solenopsis*, *Crematogaster*, *Attini* and *Camponotus*, to name a few, are similar.

Variability in color may sometimes be explained on the basis of temperature and humidity. An ant, such as *Myrmica brevinodis*, reared under cool and humid conditions may be darker than one of the

same species reared under warm and dry conditions. In a given locality where both *brevinodis* and *sabuleti americana* occur, the former is darker in color and likely to be found in the cooler and damper spots, the latter on the better drained, hence dryer, and sunnier places. *Sabuleti nearctica*, in its type locality and generally where taken in North Dakota, is a dark subspecies found in cool, damp, sites; *americana*, often occurring close by but in warmer and drier areas, is paler.

The revision follows the plan indicated in the 1939 paper of treating as species certain forms which some earlier authors had considered to be subspecies or varieties of *rubra* or *scabrinodis*, the two generalized species. Indeed, half of the 124 described forms known in 1934 were called subspecies or varieties of *scabrinodis*. The term "variety" was abandoned by myself years ago although it may have utility in some cases. In fact, I had used it only four times previously for new ants. Originally I had followed Dr. Wheeler in using quadrinomials in *Myrmica*. Recent practice in Europe also is to elevate certain forms, although some workers are still creating "varieties." Holgersen (1940, 1942, 1944) regards *ruginodis*, *laevinodis*, *scabrinodis*, *rugulosa*, *sulcinodis*, *lobicornis*, *schencki* and *sabuleti* as distinct species in Norway. Stärcke (1942 a and b, 1943) similarly regards these as distinct species in Europe. Donisthorpe (British Ants, 1927) has long considered those of the above forms occurring in Great Britain, except *sabuleti*, as "good though closely allied species."

The varietal status is here retained, however, for three North American ants which were so originally described and which future study may show to be three modern instances of importation from Europe, thus not deserving to be named at all. Certain doubtful or incompletely known palaearctic varietal names are also provisionally retained. A number of the forms from Europe are not described, but references are given to them. It is felt that they are the result of hair-splitting distinctions, which if consistently adopted would lead to the giving of a new name to almost every individual ant. This, obviously, does not subserve the purposes of classification.

For additional bibliography and synonymy prior to 1893, see the Catalogus Hymenopterum (Dalla Torre, 1893) and prior to 1922, the Genera Insectorum (Emery, 1922).

#### AFFINITIES

The genus most nearly related to *Myrmica* is *Manica* Jurine (Wheeler emend.) which has been considered a subgenus of *Myrmica*. I believe, however, that it would be better to regard it as a distinct genus, because of the following peculiarities:

The epinotum of the worker is unarmed instead of possessing distinct spines.

The teeth on the mandibles of the worker are more numerous and smaller.

The male has worker-like mandibles, whereas in *Myrmica* these organs are weaker and have fewer teeth.

The genitalia of the male can be readily distinguished from those of any *Myrmica* by the volsellae, which have a distinct lobe-like prolongation of the angle opposite the hook. The nearest approach to this

characteristic is found in *Myrmica rubra* (L.) in which, however, the prolongation is acutely angular. The genus *Manica* includes one Eurasian species, *M. rubida* (Latr.), and five American species, *aldrichi* Wheeler, *bradleyi* Wheeler, *hunteri* Wheeler, *mutica* Emery, and *parasitica* Creighton, parasitic upon *bradleyi*. The species, both in Europe and in North America, inhabit mountainous regions but are found only at moderate elevations nesting in comparatively dry and sandy situations.

Next to *Manica* the genus *Aphaenogaster* Mayr seems closest to *Myrmica* but differs clearly in the simple posterior tibial spurs, in slender habitus and in having the petiole always distinctly pedunculate. The genitalia of the male, nevertheless, show that *Aphaenogaster* is fairly close to some forms of *Myrmica scabrinodis* Nyl. and the relationship between the two genera may prove to be even closer when the males of *M. ritae* Emery and *margaritae* Emery are discovered.

#### FOSSIL RECORD

The fossil record of *Myrmica* is limited to one species, *M. longispinosa* Mayr., of the Baltic Amber (Oligocene), known from the holotype and one additional specimen identified by Dr. Wheeler (1914, pp. 59-60). Mayr believed it to be closely related to the recent *M. sulcinodis* Nyl. *Nothomyrmica intermedia* Wheeler, from the Baltic Amber, closely resembles *Myrmica* and was excluded from that genus only because it lacks spurs on the middle and hind tibiae. Thus far no *Myrmica* has been taken in the Florissant shales of Colorado (Miocene) or other North American deposits, although Dr. Carpenter (1930) has described several species of *Aphaenogaster* and other Myrmicinae from the former locality. As he has shown, the *Myrmica* sp. of Scudder from the Green River formation (Middle Eocene) is not a *Myrmica*, nor, indeed, a Formicid.

#### DISTRIBUTION

The species of *Myrmica* are holarctic, occurring in Asia from Northern Siberia to Formosa, the mountains of Burma, Persia and in the Caucasus; in Europe from Scandinavia to Greece, Italy and Spain; in North America from the Arctic Circle to the highlands of Mexico. There are two North African records in the literature. Forel cites *M. laevinodis* from Algerian gardens and Santschi (1931) lists the mountains of Tunis and the Iberian Peninsula as the range of *M. scabrinodis* var. *aloba* Forel. Dr. C. Menozzi has sent me several workers of *M. scabrinodis* subsp. *rolandi* Bond. from Asni, Morocco. These two forms of *scabrinodis* are widespread in the Iberian Peninsula, but whether they have been introduced into North Africa by human agencies or by winged fecundated females carried by winds across the Straits of Gibraltar, is not known. Apparently they have existed in North Africa for some time since both localities are many miles inland. No forms even closely related to *Myrmica* have been taken in Ethiopia, Australia or South America.

#### COMPARISON OF THE PALEARCTIC AND NEARCTIC SPECIES

Before proceeding to a discussion of the origin of the species of *Myrmica* of the two continents, the forms of these two major divisions



*M. wheeleri*  
*M. punctiveniris*  
*M. punctiveniris* subsp.  
*pinetorum*

Of the 137 described forms, only 19, or 14 per cent, are nearctic. These figures show a striking preponderance of palaearctic forms. Many of the European names, however, have been coined for small variations in the workers which I have considered, in the North American collection, to be normal variants of a single form.

A more accurate analysis of the forms of the two regions may be made from the two following lists. The first includes only those forms which are closely allied in all three castes or clearly related where only the worker caste is known:

## PALEARCTIC

*M. laevinodis*

*M. lobicornis*

forms

*M. scabrinodis*

*M. sabuleti*

*M. schencki*

## NEARCTIC

*M. laevinodis* varieties

*bruesi*

*champlaini*

*neolaevinodis*

*M. lobicornis* subsp.

*fracticornis*

*M. scabrinodis* subsp. *mexicana*

*M. sabuleti* subsp.

*americana*

*hamulata*

*nearctica*

*spatulata*

*M. schencki* subsp. *emeryana*

The second list, which follows below, includes those species which are distinctly different. I must omit species from this list which were described inadequately, or of which I have not seen specimens. I am also omitting the two supposedly parasitic species.

## PALEARCTIC

*M. kurokii*

*M. margaritae*

*M. moravica*

*M. pachei*

*M. ritae*

*M. rugosa*

*M. smythiesi*

*M. sulcinodis*

## NEARCTIC

*M. punctiventris*

*M. wheeleri*

From the two selected lists presented above it will be seen that, of the fifteen distinctly different species, only five are common to the entire Holarctic Region. One of these, *M. laevinodis*, is included because it has three varieties, *bruesi*, *champlaini*, and *neolaevinodis*, described from the northeastern coast of North America. They may be importations. Another is included (*M. scabrinodis*) because of a subspecies in Mexico (*mexicana*).

Of the remaining ten species, two are peculiar to the Nearctic Region. It is a mere coincidence that this fraction corresponds somewhat with the 14 per cent arrived at by taking all of the described forms at their face value.

The remaining eight species are peculiar to the Palaearctic Region. One is restricted to southeastern Europe (*M. moravica*); another, *M. sulcinodis*, is widely distributed in Eurasia; the remaining six are peculiarly Asiatic. Of these latter species three, *margaritae*, *ritae*, and *kurokii* are restricted to eastern Asia.



## ORIGIN OF THE SPECIES OF MYRMICA

To summarize, then, we may say that of the several distinct species of *Myrmica*, the three most widely distributed and variable species, omitting *laevinodis* and *scabrinodis*, are truly holarctic; two are more or less widely distributed; two species are nearctic; one is of southeastern European provenience, while the remaining six are peculiarly Asiatic.

The single fossil record from the Baltic Amber proves that the genus was established by the Oligocene. It seems probable that the genus was holarctic during the Early Tertiary for conditions were mild and communication between the Palaearctic and Nearctic Regions is undoubted.

Such a holarctic distribution during preglacial times would explain the present distribution of the species. The most specialized species, which are now found in eastern Asia, may have had a wider distribution but became limited to the southern and eastern part of their range during the Pleistocene. The two nearctic species, one now found on the Atlantic Coast, the other in the mountains of Arizona, could have been survivors of the glaciation, the former in the southern part of its range, the Southern Appalachians, the latter about where it now is, since that region has probably not undergone extensive glaciation. The widespread extension of the many forms of *M. scabrinodis* could have taken place after the Pleistocene. In the Palearctic Region they could have spread from eastern Asia, in the Nearctic Region from a haven in the southern Rocky Mountains. The great variability of such species as *M. rubra* and *scabrinodis* may be due to such a comparatively recent restocking of the major part of the Holarctic Region. Perhaps this influx of ants following the recession of the glaciers and reaching into new and varied environments has led to modifications of structure. For such an ancient and conservative group of animals as the ants, the time since the Pleistocene may not have sufficed for the stabilization of certain structural modifications. This would account for our finding so many puzzling series of intermediate forms at the present time.

## KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA WORKERS

1. Gaster punctate..... 2  
Gaster smooth..... 3
2. Length 4-4.7 mm.; epinotal spines about  $1\frac{1}{2}$  times the distance between their bases and deflected apically..... **punctiventris**  
Length 3.5-3.9 mm.; epinotal spines only slightly longer than the distance between their bases, not deflected apically..... **punctiventris** subsp. **pinetorum**
3. Antennal scape bent angularly at the base, the bend equipped with a tooth or lamina..... 4  
Antennal scape evenly bent, not equipped with a tooth or lamina..... 11
4. Antennal scape with a lamina completely around the bend and prolonged along the posterior side to an appreciable extent..... 5  
Antennal scape different..... 7
5. Posterior extension of the lamina projected backwards near the base in an acute tooth or hook..... **sabuleti** subsp. **hamulata**  
Lamina otherwise..... 6
6. Bend of the scape with a high, suberect lamina at the base; ventral margin of postpetiole nearly flat (Fig. 1)..... **sabuleti** subsp. **americana**  
Bend of the scape with a low, thickened ridge at the base, posteriorly prolonged along the side in a horizontal and much wider extension, **sabuleti** subsp. **nearctica**

7. The bend with a high, thin lamina produced along the anterior side and downward, where deflected posteriorly to the base of the scape (Fig. 2),  
*schencki* subsp. *emeryana* ..... 8  
 Bend of the antennal scape otherwise..... 8
8. Bend, from above, with a broad, spatulate extension of the lamina medially and slightly upwards..... *schencki* subsp. *spatulata*  
 Bend of antennal scape otherwise..... 9
9. Antennal scape at the bend laterally compressed, i.e., laterally in the same sense as when used regarding the head, with a small transverse ridge across the bend..... *scabrinodis* subsp. *mexicana*  
 Antennal scape dorso-ventrally compressed at the bend and with a small tooth or lamina..... 10
10. Length 4-6 mm.; epinotal spines projected backwards at about 30° (Fig. 3)..... *lobicornis* subsp. *fracticornis*  
 Length 3.3-4 mm.; epinotal spines projected backwards at 40°-55°; thorax much paler than head and gaster..... *schencki* subsp. *tahoensis*
11. Epinotal spines much shorter than the declivity ventral to them..... 12  
 Epinotal spines nearly as long to longer than the declivity ventral to them, or body strongly shining..... 14
12. Antennal scape ventral and median to the bend with a distinct keel on the postero-medial margin; body very finely sculptured,  
*brevinodis* subsp. *discontinua*  
 Bend of scape with a faint indication of a posteromedial keel or tooth..... 13
13. Epinotal spines deflected apically..... *wheeleri*  
 Epinotal spines not deflected apically..... *brevinodis* subsp. *brevispinosa*
14. Body strongly shining, sculpturing largely smooth..... 16  
 Body largely dulled by sharp and deep sculpturing..... 15
15. Head and gaster dark brown to black, thorax and appendages red-brown,  
*brevinodis* subsp. *sulcinodoides*  
 Color lighter..... *brevinodis* and its subsp. *kuschei* of Alaska
16. Medial funicular joints quite as broad as long..... 17  
 Medial funicular joints longer than broad..... *laevinodis* var. *bruesi*
17. Epinotal spines as broad at the base as long..... *laevinodis* var. *champlaini*  
 Epinotal spines longer..... *laevinodis* var. *neolaevinodis*

#### KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA FEMALES

1. Gaster punctate..... 2  
 Gaster smooth..... 3
2. Length 5-5.7 mm.; epinotal spines long and curved slightly downwards,  
*punctiventris*  
 Length 4.7-5 mm.; epinotal spines short and straight,  
*punctiventris* subsp. *pinetorum*
3. Antennal scape bent angularly at the base and equipped with a dorsal tooth or lamina..... 4  
 Antennal scape evenly bent, not equipped with a dorsal tooth or lamina..... 11
4. Antennal scape with a lamina completely around the bend and prolonged along the posterior side to an appreciable extent..... 5  
 Antennal scape different..... 7
5. Posterior extension of the lamina projected backwards near the base in an acute tooth or hook..... *sabuleti* subsp. *hamulata*  
 Lamina otherwise..... 6
6. Bend of the scape with a high, suberect lamina at the base,  
*sabuleti* subsp. *americana*  
 Bend of the scape with a low, thickened ridge at the base, posteriorly prolonged along the side in a horizontal and much wider extension,  
*sabuleti* subsp. *nearctica*
7. The bend with a high, thin lamina produced along the anterior side and downward, where deflected posteriorly to the base of the scape,  
*schencki* subsp. *emeryana*  
 Bend of the antennal scape otherwise..... 8
8. Bend, from above, with a broad spatulate extension of the lamina medially and slightly upwards..... *schencki* subsp. *spatulata*  
 Bend of antennal scape otherwise..... 9

9. Antennal scape at the bend laterally compressed, i.e., laterally in the same sense as when used regarding the head, with a small transverse ridge across the bend. . . . . *scabrinodis* subsp. *mexicana*  
Antennal scape dorso-ventrally compressed at the bend and with a small lamina . . . . . 10
10. Antennal scape with a lamina; length 4.7–6.4 mm.; pronotum coarsely reticulate anteriorly . . . . . *lobicornis* subsp. *fracticornis*  
Not so . . . . . 11
11. Antennal scape with a lamina; length 4.5–5 mm.; pronotum transversely rugose . . . . . *schencki* subsp. *tahoënsis*  
Not so . . . . . 12
12. Length 4.5–5.2 mm.; thorax with moderately abundant, fine and acute hairs . . . . . *wheeleri*  
Size larger . . . . . 13
13. Antennal scape distinctly compressed at the base and with a slight dorso-median keel; length 5.3–6.3 mm.; color largely brownish red, . . . . . *brevinodis* subsp. *brevispinosa*  
Not so . . . . . 14
14. Length about 5.6 mm.; color of body dark brown, appendages yellow brown; scutum of mesonotum with coarse, shallow pits at the base of the sculpturing . . . . . *brevinodis* subsp. *kuschei*  
Not so . . . . . 15
15. Color of body blackish brown, appendages brown; length 6.3–7.2 mm., . . . . . *brevinodis* subsp. *sulcinodoides*  
Not so . . . . . 16
16. Antennal scapes stout; antero-median and parapsidal dark brown blotches on the mesonotum, pronotum lighter . . . . . *brevinodis*  
Antennal scapes slender; pronotum dark brown, scutum of mesonotum much paler and with a posteromedian darker blotch. . . . . *laevinodis* var. *bruesi*  
The females of *brevinodis* subsp. *discontinua* and *laevinodis* varieties *neolaevinodis* and *champlaini* are unknown.

#### KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA MALES

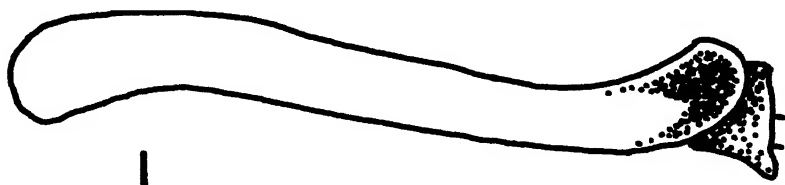
The genitalia, particularly the volsellae, offer more reliable characters for separating the species and subspecies, but cannot easily be put in a Key.

The "Antennal scape length" is given as the number of succeeding joints which, together, are as long as the scape.

1. Gaster punctate . . . . . 2  
Gaster smooth . . . . . 3
2. Antennal scape length 6 . . . . . *punctiventris*  
Antennal scape length 2 . . . . . *punctiventris* subsp. *pinetorum*
3. Antennal scape length 2 . . . . . 4  
Antennal scape length 3–7 . . . . . 6
4. Antennal scapes distinctly incrassate medially; scape length 2–3, . . . . . *sabuleti* subsp. *hamulata*  
Antennal scapes subcylindrical . . . . . 5
5. Size 5–6.3 mm. . . . . *brevinodis*  
Size 6.3–7.2 mm. . . . . *brevinodis* subsp. *sulcinodoides*
6. Antennal scape length 3 . . . . . 7  
Antennal scape length 4–7 . . . . . 11
7. Volsellae of genitalia without median tooth . . . . . *wheeleri*  
Volsellae of genitalia toothed . . . . . 8
8. Size 3.5–4 mm. . . . . *schencki* subsp. *tahoënsis*  
Size 4.6–5.6 mm. . . . . 9
9. Antennal scape length 3–4; scapes slightly bent medially, . . . . . *brevinodis* subsp. *brevispinosa*  
Antennal scape length 3 or less; scapes slightly bent at the base . . . . . 10
10. Antennal scape length slightly less than 3; about  $2\frac{1}{2}$  times as long as broad; color brown . . . . . *sabuleti* subsp. *nearctica*  
Antennal scape length 3; about 3 times as long as broad; color dark brown, . . . . . *schencki* subsp. *emeryana*

11. Antennal scape length 6-7; scutum of mesonotum completely sculptured, partly obscuring Mayrian furrow.....*scabrinodis* subsp. *mexicana*  
Antennal scape length 4-6; scutum of mesonotum largely smooth and shining, Mayrian furrow distinct.....12
12. Antennal scape length 4-5, typically 4; scape  $\frac{1}{4}$ , or less, as broad as long.....*sabuleti* subsp. *americana*  
Antennal scapes longer and more slender.....13
13. Antennal scape length 5-6, typically 6; scape one-fifth or more, as broad as long.....*lobicornis* subsp. *fracticornis*  
Antennal scape length 6; scape one-seventh as broad medially as long,  
*laevinodis* var. *bruesi*

The males of *schенcki* subsp. *spatulata*, *brevinodis* subsp. *discontinua* and *kuschei* and of *M. laevinodis* varieties *neolaevinodis* and *champlaini* are unknown.



2



3



FIG. 1. Antennal scape of *Myrmica sabuleti americana* Weber, worker.

FIG. 2. Antennal scape of *Myrmica schencki emeryana* Forel, worker.

FIG. 3. Antennal scape of *Myrmica lobicornis fracticornis* Emery, worker.

## THE HOLARCTIC SPECIES OF MYRMICA LATREILLE

*Myrmica rubra* (L.) Latreille

*Myrmica rubra* was described in the 10th edition of the *Systema Naturae* (1758, p. 983) as *Formica rubra*:

"F. testacea, oculis punctoque sub abdomine nigris."

In the 12th edition (1767) he adds:

"Habitat in Europa tuberibus graminosis; pessime nostratum pungit."

Latreille, in 1810, (Cons. Gen. Crust. Ins. 312 No. 445, 437) made *Formica rubra* the type of genus *Myrmica* and this genotype has been accepted by later myrmecologists.

In 1846 Nylander split *Myrmica rubra* into the species *laevinodis*, *ruginodis*, *sulcinodis* and *scabrinodis* but, unfortunately, did not retain the specific name of *rubra* for any ant. Emery pointed out, in 1908, that *Myrmica rubra* could only be applied to *laevinodis* and *ruginodis*, for they were the only species of *Myrmica* that could sting at all badly. He therefore made *laevinodis* and *ruginodis* subspecies of *rubra* but neglected to synonymize one of them with the typical *rubra*. The genotype, of course, must be represented by a concrete form.

The description "testacea, oculis punctoque sub abdomine nigris" fits *ruginodis* better than it does the paler *laevinodis*. Santschi (1931, p. 339) has also pointed out that, since *laevinodis* was the first species to be taken out of *rubra*, the remaining species, *ruginodis* of Nylander, becomes a synonym. I am here following Santschi in synonymizing *ruginodis*.

*Myrmica* subsp. *rubra* (L.)

*M. ruginodis*, Nylander, Act. Soc. Sc. Fennicae, 1846, 2: 929-930, pl. 18, figs. 5, 30, ♀ ♂; Finzi, Boll. Soc. Adr. Sc. Nat., Trieste, 1926, 29: 85-86, fig. 2.

*M. rubra ruginodis* of authors in *Genera Insectorum* (Emery, 1922).

*M. rubra* (L.), Santschi, Rev. Suisse Zool., 1931, 38: 330.

*M. dimidiata*, Say, Boston Jour. Nat. Hist. 1836, 1: 293.<sup>2</sup>

*Worker* (after Nylander): Length 2 lin. Similar to the preceding (*M. laevinodis*), but a little larger, very coarsely rugose, metanotum longitudinally rugose in front of the spines, spines long and the pedicel with irregular longitudinal, but not profound, rugosities. Clypeus above rather smooth. Otherwise as in the preceding.

*Female* (after Nylander): Length almost 2½ lin.

Similar to the preceding female, but colored as follows and meta-thoracic spines distinctly double the length: Dorsal surface of head fuscous, clypeus darker eyes black; between the eyes, the mandibles and antennae, testaceo-ferruginous; mandibles at the apex a little fuscous. Clypeus rather more confusedly striate than in the preceding. Metanotum and sides of thorax faintly, scutellum very distinctly,

<sup>2</sup>*Myrmica dimidiata* Say from the United States was described as "body pale yellowish: thorax somewhat tinged with piceous" "length over one-fifth of an inch;" the omitted part of the description deals with the wings and is a purely generic diagnosis. The color of the body is that of no nearctic *Myrmica* female although the size might be that of any of the forms of Eastern America. It is unsatisfactorily synonymized with the type species of the genus since the actual specimen appears to be lost and it is impossible otherwise to correlate it with known forms.

fuscous; spines very long. Wings as in the preceding. Legs entirely a pallid testaceo-ferruginous. Pedicel as in the worker.

*Male* (after Nylander): Length  $2\frac{1}{2}$  lin.

Very similar to the male of the preceding species, but a little larger, head in the first place conspicuously larger, stigma of the wings distinctly fuscous, legs long and bare. Head shining, finely and faintly rugulose; clypeus smooth and evenly convex. Wings as in the female; legs lightly pubescent, almost bare.

Figure 5 of Nylander's description is of the wing of a female. Figure 30 is of the epinotum and petiole in profile; the spines are drawn slightly deflected downward and only slightly shorter than the declivity ventral to them; the metasternal teeth are acute and directed upwards; the petiole, from apex of mid-ventral tooth to posterior margin, is distinctly longer than high and with concave anterior face and subcylindrical peduncle.

For a complete discussion of this subspecies, see Donisthorpe (1915, pp. 115-121). It is widely distributed in Europe and in western Asia.

#### *Myrmica rubra* var. *khamensis* Ruzsky

*M. ruginodis* Nyl. var. *khamensis*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc., 1915, 20: 441, figs. 22-24, ♀.

*Worker* (after Ruzsky):

Differing from the typical form by the smooth and shining infra-spinal surface of the epinotum, the basal surface also being flatter. The epinotal spines are shorter, the sculpturing of the body weaker and the color darker.

*Type Locality*: Tibet: Yangste basin, 11,400 feet, Aug. 1900, Sept. 1901 (Kozlov).

According to Ruzsky's figures the epinotal spines are distinctly shorter than the declivity ventral to them and have the apices directed upwards. The length of the petiole from apex of ventral tooth to postpetiole is a little shorter than the height at the node. The antennal scape distinctly exceeds the occipital margin and is relatively incrassate distally.

#### *Myrmica rubra* var. *kotokui* Forel

*M. rubra* subsp. *kotokui*, Forel, Sitz. der Bayerisch. Akad. Wiss., 1911: 267-268, ♀, ♂.

*Worker* (after Forel): Length 3.7-4.3 mm.

Related to *laevinodis* and *kurokii*, but much smaller than the latter and with weaker sculpturing. Head even longer than in *rugulosa*, much longer than wide, posteriorly somewhat narrower than in the middle. Antennae as in *laevinodis*, etc.; the bend of the scape some wider. Epinotal spines precisely as in *rubra*, much longer than in *laevinodis*. Petiole thicker than in *laevinodis*, somewhat as in *rubra*. Sculpturing of the head even weaker than in *laevinodis*, but the clypeus is quite wrinkled. Sculpturing of the thorax as in *rubra* (stronger than in *laevinodis*), but the epinotum between the spines is smooth. Color as in *rubra*, or somewhat darker and at the same time the reddish color somewhat paler.

*Female* (after Forel): Length 5.5 mm.

Head as in the worker, posteriorly clearly narrower than in the middle. Thorax narrower than the head. Epinotum smooth between the spines. Brown; joints, mandibles, antennae and legs yellowish to brownish yellow. Otherwise as in *rubra*.

*Male* (after Forel): Length over 6 mm.

Head somewhat longer than broad, posteriorly not broader than anteriorly (in *rubra* broader than long, posteriorly broader than anteriorly). Almost black; gaster posteriorly brownish, with lighter sutures; legs reddish; antennal scape and femora brown. Otherwise as in *rubra*.

*Type Locality*: Northern Japan (Dr. Haberer).

"Perhaps only a variety of *rubra*, but differs in the shape of the head and the smooth surface between the epinotal spines."

The single worker mentioned by Dr. Wheeler (1928) from Nikko (Hondo) (2,000-3,000 feet) seems referable to this form. As Dr. Wheeler states "the petiole and post-petiole are finely punctate and on the sides coarsely rugose, but the upper surface is smoother and on the postpetiole with a few short sulci."

#### *Myrmica rubra* var. *orientalis* Karawajew

*M. ruginodis* subsp. *orientalis*, Karawajew, Mem. Acad. Sc. Ukraine, 1926, 4: 47, fig. 1, ♂; Kuznetsov-Ugamskij, "The Ants of the South Ussuri Region (In Russian)," 1928: 37-39, figs. 22-26, ♂ ♀ ♂; Kuznetsov-Ugamskij, Zool. Anz., 1929, 83: 33, ♂ ♀ ♂.

*Worker* (after Karawajew and Kuznetsov-Ugamskij): Length 4-4.5 mm.

Head broadest anteriorly, anterior margin of the clypeus somewhat more angular than in the typical form, frontal carinae somewhat more diverging posteriorly; the antennal scape clearly surpasses the occipital margin (by a distance equal to more than its distal diameter, according to the figure). Epinotal spines longer than in the typical *M. laevinodis*, metasternal spines different, pointed or blunt. Petiole angular in profile.

Sculpture as in the typical *rubra* except for the somewhat diverging longitudinal sculpturing on the head; infraspinal surface of epinotum smooth and strongly shining; dorsal surface of pedicel finely sculptured, dully shining.

Color dark brown, legs, antennae and apex of gaster somewhat lighter.

*Female* (after Kuznetsov-Ugamskij). Length 5.7-6.2 mm.

Blackish brown. Mandibles yellowish brown. Sides of the head, thoracic sutures, pedicel, ventrally, and apex of gaster reddish brown.

*Male* (after Kuznetsov-Ugamskij). Length 4.3-5.6 mm.

Black or blackish brown. Antennae, mandibles and legs lighter or quite clearly brownish. Antennal scape equal in length to the 4 following segments together (according to Kuznetsov-Ugamskij's figure).

*Type Locality*: 30 km. north of Vladivostok. (W. Fedynsky). Siberia: Shore of Kosminschen Bay, Pestshanyi, Gulf of Amur, Okeanskaja, Tigrovaja, Bassargin, Sichoto-alin-Pasz between Kangarez and Ssutschan (Kuznetsov-Ugamskij).

***Myrmica rubra* var. *silvestrii* Wheeler**

*Myrmica ruginodis* var. *silvestrii*, Wheeler, Boll. Lab. Zool. R. Ist. Portici, 1928, 21: 100-101, ♀.

*Worker* (Original description). Length 4.5-5.5 mm.

"Of the same size as *ruginodis* (*rubra*), but differing in the following characters: Head larger and broader; antennal scapes a little more slender at the base, epinotal spines straight and distinctly shorter, petiolar peduncle shorter and the node more sharply truncated above. Sculpture coarser, the rugae on the pronotum being thicker, more rounded and very irregular and vermiculate, the declivity of the epinotum smooth and shining. Petiole and postpetiole much more strongly longitudinally rugose, the latter subopaque. Color much darker; deep piceous brown; posterior portion of head, petiole, postpetiole and most of gaster nearly black; epinotal spines and legs brownish yellow; mandibles, antennae, ventral portion of petiole and tip of gaster somewhat darker and more reddish."

"Fifteen workers from Chuzenji Lake, near Nikko (Hondo) (type-locality), Japan, and one somewhat smaller specimen from Nikko."

"This variety is quite distinct from *kotokui* in its larger size, darker color, relatively shorter epinotal spines and more coarsely sculptured petiole and postpetiole."

***Myrmica rubra* subsp. *yoshiokai*, subsp. nov.**

*Worker*: Length 4.5-5.3 mm.

Head, between the eyes, about 0.6 as broad as long (with mandibles); occipital corners evenly rounded, occipital margin straight; antennal scape slightly exceeding the occipital margin, obtusely and evenly bent at the base as in the typical *rubra*; joints 1 and 2 of the funiculus together as long as joints 3-5 together; antennal club 4-jointed. Thorax, in profile, deeply and angularly impressed at the mesoepinotal suture; epinotal spines in profile, slender, acute, projected backwards and upwards at about 45 degrees, slightly shorter than the declivity ventral to them; from above, widely diverging, about  $1\frac{1}{2}$  times as long as the distance between their bases. Petiole, in profile, slightly shorter from apex of ventral tooth to postpetiole than it is high; anterior surface weakly concave, dorsal surface weakly convex; the two meet at a slightly rounded right angle. Postpetiole, in profile, with posteriorly produced convex dorsal surface, ventral surface produced in a slight concavity anteriorly. Gaster ovate. Legs moderately long and slender.

Surface of body shining. Dorsal surface of head finely and quite regularly rugulose, sides reticulate-rugulose, base of sculpturing feebly punctate; frontal area smooth but for several median striae; clypeus with a variable number of low rugae which fade out posteriorly, sparsely punctulate interrugally; general sculpturing somewhat stronger than in the typical *rubra*. Thorax and pedicel sculptured as in the typical *rubra*; declivous surface of epinotum smooth but for faint transverse striae between the spines which grow coarser towards the dorsal margin.

Pilosity as in the typical form.

Color of the body dark brown, appendages yellow brown, slightly darker than some Japanese specimens of the typical *rubra* and much darker than the majority of European specimens.



Described from three workers from Gummaken, Japan, 14. VII.30 (H. Yoshioka coll.) in Dr. Wheeler's collection.

This subspecies is distinguished from the typical *rubra* chiefly by the shorter antennal scape and petiole and by the deeper mesoepinotal notch. It is distinctly larger than the variety *kokokui* Forel and has the epinotum between the spines faintly striate. From *kurokii* Forel it is distinct in the absence of the medial occipital convexity, differently formed pedicel, less coarse sculpturing and in other ways. From *rubra* var. *silvestri* Wheeler it differs in distinctly narrower head, differently formed pedicel, much finer and more longitudinal sculpturing and in other ways.

#### *Myrmica rubra* var. *ruginodo-laevinodis* Forel

*M. rubra* race *ruginodo-laevinodis*, Forel, Den. Schw. Ges. NW., 1874, 26: 77-79, ♀.

A name for the transitions between *rubra* (*ruginodis*) and *laevinodis*. Donisthorpe (1927, p. 123) gives the bibliography and discusses this form.

#### *Myrmica laevinodis* Nylander

*M. laevinodis*, Nylander, Act. Soc. Sc. Fennicae, 1846, 2: 927-928, pl. 18, figs. 4, 31, ♀ ♂.

*Worker* (after Nylander): Length  $1\frac{3}{4}$ -2 lin.

Very shining, dirty testaceous, eyes small, prominently rounded and black. No ocelli. Vertex and front of head a little darkened, entirely longitudinally subreticulate-striatulate, but less regularly laterally; striae from the margins to the occiput darkened; clypeus above and the frontal area smooth; mandibles about 8-dentate, apically smooth; margins of the frontal laminae suberect, a little reflexly arcuate. Antennal scapes bent basally in a small arc. Thorax narrower than the head, compressed between the meso- and metathorax, dorsally depressed; metanotum transversely rugulose in front of the spines. Pedicel almost smooth, shining, sparsely pilose. Gaster longer than the head, ovate, seen from above, a little broader than when seen from the side; dorsally sometimes less infuscated, nearly entirely fuscous; gaster marked either with little spots or large fuscous blotches, sometimes obsolete.

*Female* (after Nylander): Length  $2\frac{1}{2}$  lin.

Similar to the worker but larger, darker and more rugose. Ocelli distinct. Head fuscous, mandibles testaceous, at the apex slightly smooth, fuscous; antennae testaceous, at the apex fuscous. Mesothorax testaceo-ferruginous, otherwise ferrugineo-fuscous, epinotal spines much shortened, subdentiform. Legs entirely a sordid, pale testaceous, pubescent. Pedicel obsoletely rugulose. Gaster nearly longer and a little broader than the thorax, rather more rotund than in the worker, dorsally and medially fuscous. (Wings absent in our specimens).

*Male* (after Nylander): Length 2 lin.

Fuscous black, shining, head a little opaque. Head faintly and thinly striatulate to rugulose, small. Palpi and mandibles testaceous, about 7-denticulate, rufous at their apices. Antennae fuscous, funiculi

at least sordid rufous; scapes almost exceeding one-third of the funiculi, about as long as the 7 following joints; antennae 13-segmented. Eyes very prominent; ocelli distinct. Thorax very shining; almost all the sutures crenate; metathorax with subangular tubercles on both sides. Wings chiefly hyaline, from the stigma to the base a faint, pale cinereous, veins and stigma dilute, pale cinereous; . . . (wing venation), wings about  $2\frac{1}{4}$  lin. long. Pedicel and gaster shining. Margins of the leg segments and the entire tarsi pale testaceous, tibiae sometimes pale fuscous; long, slender pilosity.

Figure 4 of Nylander's description is of the wing of a male in which the radial vein traverses the entire length of the first cubital cell, forming a second cubital of about half the size. Figure 31 is of the epinotum and petiole in profile; the spines are about half as long as the declivity ventral to them; the petiolar peduncle is subcylindrical and the node rises smoothly but at right angles, the node being about  $\frac{3}{4}$  as high as the petiole is long between the apex of the ventral tooth and the posterior margin.

For a complete discussion of this subspecies see Donisthorpe (1915, pp. 110-114). It is widely distributed over Europe and Asia.

#### *Myrmica laevinodis* var. *bruesi* Wheeler

*M. rubra laevinodis* var. *bruesi*, Wheeler, Psyche, 1906, 13: 38.

**Original Description:** "A number of workers, females and males taken by Mr. C. T. Brues and myself during 1900 and 1902 from a few large colonies nesting under stones at the edge of Fay's Woods, Woods Hole, Mass., agree very closely with European specimens of *M. laevinodis* from Russia, Austria, Germany, England and Scotland in my collection. The thorax of the workers of the American form is smoother, more shining and less regularly sculptured than in the European specimens, but I am unable to find any other differences of importance and therefore establish this variety with some hesitation. I should be inclined to regard it as directly imported from Europe were it not that Forel has described two subspecies of *M. rubra* (*M. neolaevinodis* and *M. champlaini*) from New York and Canada respectively, both allied to the European *laevinodis* but with distinctive characters. The former has short antennae, with the tips of the scapes extending only a short distance beyond the posterior corners of the head, the latter has very short epinotal spines. It thus appears that America possesses indigenous forms closely related to *laevinodis*, just as it has long been known to possess numerous varieties of the other boreal and subboreal subspecies of *M. rubra*."

The above account and description gives the status of this ant at the present time. I find among the collections distinct polymorphism in the workers. Many workers are indistinguishable, furthermore, from typical *M. rubra rubra* and have the epinotal spines clearly longer than the distance between their bases, have the infraspinal surface transversely striate and are dark reddish-brown in color. Males taken with them have more abundant and more erect hairs on the tibiae than are found in *r. rubra*.

In 1908 (Journal Econ. Ent., 1: 337-339) Dr. Wheeler recorded this ant from the Forest Hills and Jamaica Plain region about Boston. In

1933-34 I found it very common locally in the Boston vicinity and took it also at Woods Hole. Generally it was taken in rather damp situations. One colony consisted of 1094 workers and several queens; another had eight queens. In 1940 I found it at Nahant, north of Boston on the Bay, and in 1946 again at Woods Hole. Dr. A. H. Sturtevant has had a long acquaintance with the species at Woods Hole and agrees with me in doubting its validity. Dr. Wheeler, of course, was fully aware of its provisional status. It is curious that in the approximately half century in which it should be known in Massachusetts it has not spread farther. Indeed in 1946 it was still to be found exactly where it was in 1900—at the edge of Fay's Woods (or Gardens), Woods Hole. Stray workers were taken on top of the stone wall and in the woods nearby, across from the schoolhouse on School Street. *Myrmica schencki emeryana*, a native ant, was seen here also but the nearest worker found in a casual search on one day was about 50 feet away from *laevinodis*. It would be interesting to determine what factors, including competition from native *Myrmicas* and other ants, prevent the extension of the range of *laevinodis*.

#### *Myrmica laevinodis* var. *champlaini* Forel

*M. rubra laevinodis* var. *champlaini*, Forel, Mitt. Naturh. Mus. Hamburg, 1901, 18: 80-81, ♀.

*Worker* (after Forel):

Very similar to the foregoing (*M. neolaevinodis*), the metanotum, however, has only two strongly triangular teeth, or, if one prefers, two very short spines, which are not longer than they are broad at their bases. The sculpturing on the head and thorax is denser and stronger, almost as in *ruginodis*. The declivity of the metanotum, however, is entirely smooth and shining, and the pedicel has, only on the sides a few longitudinal impressions. Reddish with brownish head and gaster. Petiole very short, its posterior surface, from the apex, is as long as the anterior declivity, the latter somewhat concave. Antennal scape as in *neolaevinodis*, or even somewhat shorter; the scape does not exceed the occipital margin.

"Quebec, Canada. On the border of a meadow path, near the harbor, collected by myself.

"Both these forms are closely related to *laevinodis*, but with American peculiarities. While in *neolaevinodis* the spines are at least as strong as in *laevinodis*, they are extraordinarily stunted in *champlaini*."

#### *Myrmica laevinodis* var. *europaea* Forel

*M. rubra* subsp. *champlainii* var. *europaea*, Forel, Rev. Suisse Zool., 1911, 19: 457, ♀.  
*M. laevinodis* var. *europaea*, Finzi, Boll. Soc. Adriatica Sc. Nat. Trieste, 1926, 29: 84, ♀.

*Worker* (after Forel):

Spines dentiform as in the type of the subsp. (*champlainii*). Peduncle of the petiole more distinct but shorter than in *laevinodis*. Color of a pale *laevinodis*. Sculpture of *laevinodis*.

*Type Locality*: Norway: Bredheim, Nordfjord (Prell).

*Myrmica laevinodis* var. *minuta* Ruzsky

*M. laevinodis* var. *minuta*, Ruzsky, Formic. Imp. Rossici, 1905: 670, ♀.

*Worker* (after Ruzsky): Length 3.5–3.8 mm.

Differing from the typical *laevinodis* in its small stature and the form of the petiolar node, which, dorsally, is broader and flatter; this and the postpetiole are somewhat dull and more sharply sculptured. Eyes somewhat larger and more convex. Segments 2–5 of the antennal funiculi are quite as broad as long. Epinotal spines as in the typical form. Color somewhat darker (head and gaster dorsally dark brown). Somewhat thicker upright hairs on the body.

*Type Locality*: Pamir: Andermanyn Pass, 28.VI.95.

*Myrmica laevinodis* var. *neolaevinodis* Forel

*M. rubra* v. *neolaevinodis*, Forel, Mitt. Naturh. Mus. Hamburg, 1901, 18: 80, ♀.

*Worker* (after Forel): Length 4.3 mm.

Brown with reddish legs and red-brown antennae. The antennal scape is strongly bent as in *laevinodis* and somewhat shorter (extending past the occipital margin only a little). The medial funicular segments are quite as broad as long (somewhat longer than broad in *laevinodis*). Petiole considerably shorter, with scarcely concave (almost flat) anterior surface. The antennae, moreover, are somewhat shorter and thicker. The sculpture of the head and thorax is somewhat stronger. Otherwise as in *laevinodis*.

From New York, imported alive with Iris roots to the Plant Quarantine Station in Hamburg.

*Myrmica laevinodis* var. *tenuispina* Forel

*M. rubra laevinodis tenuispina*, Forel, Ann. Mus. Zool. St. Petersburg, 1904, 8: 374, ♀.

*Worker* (Cotype). Length 4.4 mm.

Head 0.6 as broad between the eyes as long (with mandibles), occipital corners and posterior margin evenly rounded, eyes about  $\frac{1}{4}$  closer to the anterior clypeal margin than to the occipital margin; anterior clypeal margin distinctly convex; antennal scape exceeding the occipital margin by about twice its distal diameter, evenly bent at the basal  $\frac{1}{4}$ – $\frac{1}{5}$ ; joints 1 and 2 of the funiculus together about equal to joints 3–5 together, antennal club 4-jointed. Thorax, in profile, evenly convex to the shallow, broadly depressed, mesoepinotal suture; epinotal spines slender, bluntly tipped, narrow at the base, projected backwards and upwards at about 40 degrees, a little shorter than the declivity ventral to them; from above, distinctly longer than the distance between their bases, moderately diverging. Petiole, in profile, a little longer from apex of ventral tooth to postpetiole, than it is high; peduncle with converging margins, node rising evenly and forming an anterior face of slight concavity which forms a rounded right angle with the weakly convex dorsal surface. Postpetiole, in profile, with distinctly convex dorsal, and weakly convex ventral, surfaces. Gaster sub-elliptical. Legs moderately long and slender.

Dorsal surface of head, including clypeus, longitudinally rugulose, sides reticulate-rugulose; frontal area distinct, rounded posteriorly, smooth and shining; base of sculpturing distinctly punctate. Thorax

shining, dorsal surface sparsely and longitudinally rugose-vermiculate, more rugose posteriorly, sides rugose, somewhat reduced in an antero-dorsal area; infraspinal surface of epinotum transversely striate. Pedicel rugulose-punctate, more sparsely dorsally. Base of gaster striate, otherwise smooth and shining.

Hairs of body moderately abundant, comparatively fine and acute; of appendages more abundant, reclining, subappressed on the legs; antennal club with coarse, appressed pubescence.

Color yellowish brown (darker than in the typical *laevinodis*), dorsal surface of head and median dorsal surface of gaster darker brown.

*Type Locality*: Ferghana: Kugart R., 6,-8,000 feet, 5.VIII.1895 (Kirzinskiz); Eastern Buchara; Karategin, Kala-i-choit, 21.VII, Tabidara-zagyrdescht, 17.VI, Darvas, Tasch-Kurgan, 22.VIII.1897 (Kaznakov), Samarkand.

### *Myrmica smythiesi* Forel

*M. smythiesi*, Forel, Rev. Suisse Zool., 1902, 10: 226-227, ♀.

*Worker* (Cotype): Length 4.4 mm. (Length 3.4-4.5 mm., Emery).

Occipital margin straight; corners evenly rounded; clypeus produced slightly over the base of the mandibles in about a 145 degree angle; diameter of eyes fully twice the diameter of the distal end of the antennal scape; scapes clearly exceeding the posterior margin of the head; seen from behind, in the form of a sigmoid curve bent more at the proximal portion, distal end about twice the diameter of the proximal end; antennal club 3-4 jointed, funicular joints 1-2 together distinctly longer than joints 3-5 together; joints 3-6 of funiculus about as broad as long. Thorax, in profile, convex to the shallow mesoepinotal impression; epinotal spines, in profile, produced backwards and upwards at about a 50 degree angle, rather slender and acute, distinctly shorter than the declivity ventral to them; from above, about as long as the distance between their bases, widely diverging. Petiole, in profile, distinctly pedunculate, anterior face smoothly concave and meeting the slightly convex dorsal surface at a rounded right angle, distinctly longer from apex of ventral tooth to postpetiole than high. Postpetiole, in profile, distinctly higher than the petiole, about as long as high, anterior margin convex, posterior margin nearly plane. Gaster ovate. Legs moderately long and slender.

Surface of head rather finely and regularly sculptured, clypeus with about 8 rugae between the frontal carinae, frontal area clearly indicated, smooth and shining except at the striate margins; dorsal area finely and regularly rugulose, sides similar but with a few reticulations. Dorsal surface of thorax irregularly reticulate-vermiculate, sides rugose, somewhat vermiculate anteriorly. Pedicel regularly and finely rugulose, except on the dorsal surface of the petiole, densely punctate on the petiole, less on the postpetiole. Gaster smooth and shining but for short, fine basal striations. Legs and antennae shining, finely striate-punctate.

Pilosity rather scanty, fine, moderately long, mostly truncate dorsally, subappressed on the appendages; antennal club pubescent.

Color of body dark brown, gaster blackish brown, lighter apically; appendages brown.

*Type Localities:* Himalayas, 7,-12,000 feet, Deoban, 8,500 feet (Smythies); North West Himalaya (Gamble).

*Other Localities:* East Turkestan, East Siberia, Altai, 2,500 m. (after Emery); Middle Ussuri, Siderni (Forel).

The affinities of this species seem with *M. rugosa* and, to a lesser extent, with *M. rubra*. The genitalia of the male of the subsp. *dshungarica* is distinct from that of any other form examined.

### ***Myrmica smythiesi* var. *bactriana* Ruzsky**

*M. smythiesi* var. *bactriana*, Ruzsky, Ann. Mus. Zool. Petrograd, 1915, 20: 438-439, figs. 16-18, ♂ ♂.

*Worker* (after Ruzsky): Length 4-4.5 mm.

Epinotal spines shorter than in the type of the species, straight and slightly blunted apically; petiole a little shorter.

Sculpturing of the body, especially on the sides, rougher and more like in *dshungarica*.

Color darker than in the type of the species, thorax red brown, head and upper part of gaster blackish brown.

*Male* (after Ruzsky): Length 5-5.2 mm.

Antennal scape much as in *M. laevinodis*, about equal to the 6 following joints together, very feebly bent at the base and almost straight, about  $\frac{1}{2}$  as long as the flagellum; antennal club 5-jointed. Epinotal declivity with blunt protuberances. Petiole, from above, rounded.

Surface of head nearly dull or a little shining, finely rugose, finely and densely punctate on the sides and back; clypeus smooth and shining. Thorax with longitudinal rugae but mostly more or less smooth; sides with rounded and shallow rugae. Petiole nearly smooth. Gaster smooth and shining.

Antennal scapes and legs with oblique hairs only.

Color blackish brown, tarsi and exposed parts of genitalia brownish. Wings with a brownish cast.

*Type Locality:* Tibet: Darendo, Upper part of Yangtse basin, August 8, 1900 (Kozlov).

### ***Myrmica smythiesi* subsp. *cachmiriensis* Forel**

*M. smythiesi* subsp. *cachmiriensis*, Forel, Rev. Suisse Zool., 1904, 12: 23, ♀.

*Worker* (after Forel): Length 3.4-3.8 mm.

Differing from the typical species in its pedicel which has a very fine sculpture, almost dull, very finely reticulate-punctate; metanotum partly very finely wrinkled. The sculpturing of the head is a little more regularly wrinkled. Head and thorax subopaque. The spines are longer than their bases and, above all, much more slender. The peduncle of the petiole is longer, almost as long as the node, and is more abrupt anteriorly. The mesoepinotal impression is very profound, again more than in the type of the species, and the mesonotum has a median transverse impression. The posterior margin of the head is also more transverse, with the occipital angles well marked. Of a black ebony, varying to blackish brown, with the legs, antennae and margins of the mandibles brown.

*Type Locality:* Cachmir: Sind Valley, 2,286-2,438 m. (Wroughton).

***Myrmica smythiesi cachmiriensis* var. *lutescens* Forel**

*M. smythiesi cachmiriensis* var. *lutescens*, Forel, Rev. Suisse Zool., 1904, 12: 23, ♀.

*Worker* (after Forel): Length 3.2–3.7 mm.

Entirely dull yellow. Sculpturing identical with *cachmiriensis*, but less close and more shining. Peduncle of the petiole longer than the node; the latter more rounded.

Cachmir (Smythies):

"I possessed this variety a long time but did not have enough to determine it.

"It seems to constitute, with the preceding, a single race, considerably distinct from *carbonaria* Forel and the var. *rupestris*."

***Myrmica smythiesi* subsp. *carbonaria* Forel**

*M. smythiesii* v. *carbonaria*, Forel, Rev. Suisse Zool., 1902, 10: 227, ♀.

*Worker* (after Forel): Length 4 mm.

Color and pilosity of the var. *rupestris*; pilosity a little stronger. But the insect is more slender, the head narrower, the mesonotum more elevated (as in *rugosa*), the spines very slender, a little longer than the distance between their bases, strongly diverging, directed above and behind but more upright than in the typical species. The head, thorax and pedicel are entirely dull, densely and finely reticulate-punctate between the wrinkles.

"A single specimen from Pachmarhi (Schurr). I have perhaps wrongly attached this form, which has the appearance of a *Leptothorax*, to *M. smythiesii*. It is perhaps a separate species. The pedicel has exactly the form of that in *smythiesii*."

***Myrmica smithiesi* subsp. *dshungarica* Ruzsky**

*M. rugosa dshungarica*, Ruzsky, Formic. Imp. Rossici, 1905: 661–662, ♀.

*M. smythiesi dshungarica*, Emery, Deutsch. Ent. Zeitschr., 1908: 169, ♀.

*Worker*: Length 4.3–5 mm. (3.5–4.5 mm., after Emery).

Clypeus produced anteriorly over the base of the mandibles in the form of a 100-degree evenly rounded angle; eyes rather small, less than twice in diameter the diameter of the distal end of the antennal scape; antennal scapes barely extending to the occipital margins; seen from above, in the form of a long drawn-out sigmoid curve, evenly bent at the basal  $\frac{1}{8}$ , the basal diameter slightly over  $\frac{1}{2}$  the distal diameter; antennal club 4-jointed, joints 1–2 of funiculus equal in length to 3–5 together. Thorax in profile, slightly compressed, with distinct, though rounded and shallow, mesepinotal impression; epinotal spines, in profile, projected backwards and upwards as a 40–45 degree angle, stout, triangular with acute, deflected apices, appreciably shorter than the declivity ventral to them, from above, shorter than the distance between their bases, diverging. Petiole, in profile, with distinctly concave anterior face meeting the nearly flat dorsal surface at a sharp right angle, about as long from apex of ventral tooth to postpetiole as it is high; postpetiole, in profile, as high as the petiole and higher than its length, dorsal surface convex, ventral surface feebly convex. Gaster ovate. Legs of moderate length.

Surface of head between the frontal carinae moderately rugose, reticulate-rugose laterally, frontal area and posterior part of clypeus conspicuously smooth and shining, clypeus strongly rugose. Dorsal surface of thorax irregularly reticulate, becoming more rugose posteriorly, sides rugose. Dorsal surface of petiole irregularly wrinkled, sides more regularly vermiculate-rugose; dorsal surface of postpetiole strongly punctate, mostly smooth or a little sculptured, sides vermiculate-rugose. Gaster smooth and shining. Antennae and legs shining.

Pilosity moderately abundant, fine, acute, sub-appressed on the legs and antennae; antennal club with appressed pubescence.

Color red-brown, head and gaster dark brown; pilosity yellow.

*Female* (Dealate): Length 5.8 mm.

Similar to the worker. The epinotal spines, however, are shorter, the sculpturing of the head coarser, the pilosity more abundant and the color lighter. Scutum of the mesonotum anteriorly with an irregularly triangular, finely punctate, area from which extend posteriorly several regular rugae and laterally a series of coarse, irregular vermiculations; sides of thorax rugose; pronotum reticulate only anteriorly.

*Male*: Length 4.5–5.1 mm.

Clypeus produced in a rounded anterior margin over the mandibles; antennal scape equal in length to the following 5–6 segments together, slender, bent evenly at the basal  $\frac{1}{4}$ , slightly greater in diameter distally than proximally; antennal club 5-jointed. Epinotal declivity with two, low, inconspicuous gibbosities or none. Petiole as high as long, anterior face concave, dorsal part in the form of an evenly convex node, ventral surface slightly convex, ventral tooth practically absent. Postpetiole slightly higher than the petiole and than it is long, convex above and below. Gaster long-ovate. Legs moderately long and slender. Sagittae of genitalia with 24–26 serrations; volsellae as illustrated.

Surface of the head densely punctate, finely and irregularly vermiculate, with more or less regular longitudinal rugae between the frontal area and the anterior ocellus; frontal area clearly delimited, triangular with rounded posterior margins, finely punctate. Thorax shining, variably rugose-punctate. Pedicel finely punctate with a few marginal faint rugosities, a mid-dorsal area on the petiole and a larger dorsal area on the postpetiole smooth and shining. Gaster smooth and shining.

Pilosity moderately abundant, very fine and acute, subappressed fine hairs on the appendages; appressed pubescence on the antennal clubs.

Color black, appendages and apex of gaster dark brown. Pilosity pale yellow. Wings hyaline with a brownish cast, veins and stigma brown.

*Type Locality*: Tscunyetschi Region (Dshungaric Altai), altitude 2,000 meters, border of an alpine meadow. Taken by Tsapaschnikoff, March 29, 1902.

*Other Localities*: Turkestan: Karkara, Central Tian-Schan, 2,–2,600 mm.; Dshityoguz, S. of Tssykkul Lake, alt. 2,600 meters (N. N. Kuznetsov- Ugamskiji); Za-Tlijsk, Alatau Mts. (Dshenishke). Siberia: Issil-Kul (no collector).



***Myrmica smythiesi* subsp. *exigua* Ruzsky**

*M. smythiesi* subsp. *exigua*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd; 1915, 20: 440, figs. 19-20, ♀ ♂.

***Worker* (after Ruzsky):**

Distinguished by shorter, thicker and wider epinotal spines. These are broad at the base, then narrow abruptly apically to slender, though blunted, apices.

Head a little shorter and wider than in *bactriana*; clypeus produced anteriorly in the form of a rounded angle; antennal scape shorter and thicker.

***Male* (after Ruzsky):** Length 5 mm.

Thorax thinner than in *bactriana* and body generally smaller. Head and thorax dull and finely rugulose, otherwise as in *bactriana*.

Color brighter and dark brown. Wings with a darker cast.

***Type Locality.*** Bar-Chu River, 12,000 feet, Yangtse basin, August 2, 3, 1900 (Kozlov).

***Myrmica smythiesi* var. *fortior* Forel**

*M. smythiesi* var. *fortior*, Forel, Rev. Suisse Zool., 1904, 12: 22-23, ♀.

***Worker* (after Forel):** Length 4.2-4.5 mm.

Sculpturing stronger and less close than in the typical species. Similarly shining. Spines longer, rather longer than in their interval. Mesoepinotal impression feebler, little accentuated. Petiole a little more truncate anteriorly. Postpetiole shining (Emery). Dull brown, thorax, antennae, mandibles and legs a dull yellowish brown.

Sind Valley, 1891 m., Cachmir (Wroughton); Deota, 914 m., North West Himalaya (Smythies); East Siberia (Museum of St. Petersburg).

"This variety passes through all the transitions to the typical form and, on the other hand, to the var. *debilior* Forel and *rugosa* Mayr."

***Myrmica smythiesi* subsp. *himalayana*, subsp. nov.**

***Worker:*** Length 4.4-4.6 mm.

Closely resembling the cotype of the typical form but differing distinctly in the following characters:

Occipital margin slightly, but distinctly, impressed medially, angles evenly rounded. Epinotal spines reduced to acutely pointed teeth; seen from above, shorter than the distance between their bases, moderately diverging.

Striae at the base of the gaster almost wanting, much less distinct than in the typical *smythiesi*.

***Type Locality:*** India: Simla (Wroughton).

Described from three workers in Dr. W. M. Wheeler's collection.

The variety *bactriana* Ruzsky is described with short epinotal spines, which, however, are blunted apically but the sculpturing is rougher and the color is darker. A subspecies *exigua* Ruzsky is also described with shorter epinotal spines than in the typical species but the head is shorter and wider, the anterior clypeal border rounded, and the antennal scape shorter and thicker.

***Myrmica smythiesi* subsp. *hecate*, subsp. nov.**

*Worker*: Length 5.2–5.7 mm.

Occipital margin of head slightly impressed medially; angles evenly rounded; anterior clypeal margin produced over the base of the mandibles in a rounded lobe of about 115 degrees; antennal scape exceeding the occipital margin by a distance equal to more than its distal diameter; joints 1 and 2 of the funiculus together slightly shorter than joints 3–5 together; club 4-jointed. Thorax, in profile, feebly concave to the broad and shallow mesoepinotal impression; epinotal spines slender, acute, directed backwards and upwards at about 30 degrees, shorter than the declivity ventral to them; from above, about  $1\frac{1}{2}$  times as long as the space between the bases, feebly diverging. Petiole, in profile, longer, from apex of ventral tooth to postpetiole, than high, anterior declivity clearly concave and meeting the dorsal surface at a subangular right angle. Postpetiole, in profile, as high as long, dorsal surface convex, ventral surface nearly flat, ending anteriorly as an acute angle. Gaster subelliptical. Legs moderately long and slender.

Surface of head more coarsely sculptured than in the typical form, frontal are smooth and shining, median dorsal surface longitudinally rugulose, laterally becoming reticulate. Dorsal surface of thorax thinly and very irregularly sculptured, mostly vermiculate anteriorly and longitudinally rugulose posteriorly; sides irregularly rugulose, somewhat vermiculate anteriorly. Base of sculpturing of head and thorax mostly smooth and shining, few punctations. Sides of pedicel sparsely rugulose, densely punctate; dorsal surfaces with obscure rugulosity, densely punctate. Base of gaster with faint, sparse striae, otherwise smooth and shining. Antennal scapes sparsely and finely striate; legs microscopically striate-reticulate.

Pilosity of body moderately long, fine and acute; appendages with more numerous subappressed hairs; antennal club and tarsi with appressed pubescence.

Color dark blackish-brown, appendages dark brown.

Described from two workers with the Indian Museum labels "sweepings in grass and low herbage, Brunetti, Darjiling, 6,000 feet, 24.IX.08, No. 8607–19" and "Botanical gardens, Darjiling, 6,900 ft., 7.VIII.09, C. Paiva, No. 8609–19."

There are slight differences between these two Himalayan specimens but hardly sufficient to justify separate names.

In the length of the epinotal spines, sculpturing of the pedicel and color this subspecies resembles the subsp. *cachmiriensis* Forel. The sculpturing of the head, the occipital margin, the mesoepinotal impression and the size are quite different.

***Myrmica smythiesi* var. *rupestris* Forel**

*M. smythiesii* var. *rupestris*, Forel, Rev. Suisse Zool., 1902, 10: 227, ♀.

*Worker* (after Forel):

General habitus as in the typical form but black, with the sculpture stronger than in *rugosa*, the pedicel strongly sculptured, the scapes reticulate, the pubescence of the tibiae oblique, the petiole more elongate (much longer than broad); otherwise as in the type.

*Type Locality*: North West Himalaya: Ekra Peak, 9,500 feet (Smythies).

***Myrmica rugosa* Mayr**

*Myrmica rugosa*, Mayr, Reise Novara, Formicid., 1865: 19, note, ♀.

*Worker* (Cotypes): Length 5-6 mm.

Head about 0.65 as broad between the eyes as long (with mandibles). Occipital margin of head straight; occipital corners broadly rounded. Clypeus produced over the base of the mandibles in an angulate lobe of about 130 degrees; eyes less than twice as large in diameter as the distal diameter of the antennal scapes; scapes exceeding the posterior margin of the head appreciably; seen from above, bent smoothly at the basal  $\frac{1}{5}$  and very slightly at the distal end, distal end twice as wide as at the base; antennal club 4-jointed. Thorax, in profile, irregularly convex, distinctly impressed at the mesepinotal suture; epinotal spines, in profile, produced backwards and upwards at about a 55-65 degree angle, narrow, straight and acutely pointed, a little shorter than the declivity ventral to them; from above, about as long as the distance between their bases, diverging. Petiole, in profile, distinctly pedunculate; anterior face concave, meeting the slightly convex dorsal surface at a rounded right angle; about  $\frac{1}{5}$  longer from apex of ventral tooth to postpetiolar border than high. Postpetiole, in profile, about  $\frac{1}{5}$  higher than the petiole, slightly higher than long, dorsal margin distinctly, ventral margin slightly, convex. Gaster ovate. Legs moderately long and slender.

Surface of the head coarsely sculptured; frontal area triangular, smooth and shining; clypeus and median dorsal area coarsely rugose, sides rugose-reticulate. Entire dorsal surface of thorax coarsely reticulate-vermiculate, sides rugose, anteriorly somewhat vermiculate. Dorsal surface of petiole deeply vermiculate, sides vermiculate-punctate. Post-petiole coarsely vermiculate-punctate. Gaster smooth and shining. Legs and antennal scapes finely striate-punctate.

Pilosity moderately abundant and long, mostly obtuse dorsally; subappressed to appressed hairs on the legs and antennae, antennal club coarsely pubescent.

Color of body blackish brown, appendages dark brown; pilosity pale yellow.

*Type Locality*: Himalaya.

Males of this species have not been reported but, judging from the workers, the species seems closest to *M. smythiesi* and *M. rubra*.

***Myrmica rugosa* subsp. *arisana* Wheeler**

*M. rugosa* var. *arisana*, Wheeler, Proc. New England Zool. Club, 1930, 11: 95, ♀.

*Worker*: Length 5.6-6 mm.

Clypeus but slightly produced over the base of the mandibles and with evenly convex anterior margin; diameter of eyes nearly twice that of the distal end of the antennal scape; scape extending beyond the occipital margin by a distance equal to slightly more than its distal diameter; seen from a posterior view, bent, at its basal  $\frac{1}{5}$ , evenly inward at about 40 degrees, distal diameter about twice that of the proximal end; joints 1-2 of the funiculus together equal in length to joints 3-5 together, antennal club 4-jointed. Thorax, in profile, irregularly convex to the deep mesoepinotal suture; epinotal spines produced

backwards and upwards at a 45 degree angle, broad at the base, slender and exceptionally acute apically, longer than the declivity ventral to them; from above, feebly diverging,  $1\frac{1}{2}$  times as long as the distance between their bases. Petiole, in profile, comparatively small, anterior face feebly concave, meeting the dorsal, slightly convex, surface at a rounded obtuse angle, length from apex of ventral tooth to postpetiole equal to the maximum height. Postpetiole, in profile, distinctly higher than the petiole; produced, on the dorsal surface, backwards as a large convexity, and, ventrally, as a smaller, anterior convexity. Gaster ovate. Legs long and slender.

Surface of the head moderately sculptured and shining, clypeus with about 8 rugae between the frontal carinae, frontal area distinct, triangular, smooth but for feeble rugae, dorsal surface rugose, sides reticulate-rugose, base of sculpturing punctate. Dorsal surface of thorax coarsely and irregularly reticulate-vermiculate, sides rugose, anteriorly somewhat vermiculate. Dorsal surface of petiole densely punctate, sides thinly rugose; mid-dorsal area of postpetiole somewhat smooth, finely reticulate, remainder sulcate- or feebly rugose-punctate. Gaster smooth and shining. Antennae and legs finely striate.

Pilosity rather thin, hairs long, slender and acute, subappressed on the appendages; antennal club with appressed pubescence.

Color of body dark brown, appendages and apex of gaster yellowish brown.

*Type Locality*: Formosa: Arisan (R. Takahashi), April 24, 1928.

Six workers taken in 1932 by L. Gressitt from the type locality are a trifle smaller, darker and more shining but merely illustrate the customary variation in this genus.

*Arisana* is clearly distinct from the typical form in deeper mesoepinotal impression, longer epinotal spines and smoother sculpturing on the pedicel.

### *Myrmica rugosa* var. *debilior* Forel

*M. rugosa* var. *debilior*, Forel, Rev. Suisse Zool., 1902, 10: 228, ♀.

*Worker* (Cotypes): Length 4.2–5 mm.

Clypeus produced over the base of the mandibles as a more or less angulate flattened lobe of about 130 degrees; antennal scapes clearly exceeding the posterior margin of the head; seen from a postero-dorsal view, in the form of a sigmoid curve with the basal  $\frac{1}{4}$  evenly bent; distal end about twice the diameter of the basal end; antennal club 4-jointed. Thorax, in profile, evenly convex to the distinct, but shallow, mesoepinotal suture; epinotal spines, in profile, projected backwards and upwards at a 40–45 degree angle, slender, acute, from about as long to distinctly longer than the declivity ventral to them; from above, over  $1\frac{1}{2}$  times the distance between their bases, widely diverging. Petiole, in profile, with a distinct subcylindrical peduncle and a convex node rising evenly from the dorsal surface, posterior part of pedicel slightly pedunculate; distinctly longer from apex of ventral tooth to ventral junction with postpetiole than high at the node. Postpetiole, in profile, distinctly higher than the petiolar node or than it is long, dorsal convex surface produced posteriorly, ventral surface produced anteriorly as an acute lobe. Gaster ovate. Legs moderately long and slender.

Surface moderately and regularly sculptured, clypeus sparsely rugose, shining; frontal area distinct, smooth and shining; head longitudinally rugose, somewhat reticulate-rugose on the sides; interrugal surfaces punctate. Dorsal surface of thorax sparsely and irregularly reticulate, smooth and shining between; sides irregularly and feebly sculptured, somewhat reticulate anteriorly, vermiculate medially and rugose posteriorly; with occasional punctations. Pedicel densely punctate with a few scattered rugae. Gaster smooth and shining. Legs and antennae shining, finely punctate-striate.

Pilosity sparse, hairs long, fine, acute or truncate, subappressed on the legs; appressed pubescence on the antennal clubs.

Color of body black, appendages dark brown.

*Type Localities:* Himalaya, Deota (Smythies); Darjiling, 3,–8,000 feet, Northern India (Wroughton); Mysore (Rothney): Kāmāon (Schlagintweit).

The densely punctate pedicel and the dark color distinguish this variety from the other known forms.

### *Myrmica rugosa* var. *kirgisica* Ruzsky

*M. rugosa* var. *kirgisica*, Ruzsky, Horae Soc. Ent. Rossicae, 1903, 36: 314.

*Worker* (after Forel and Emery):

Head broader and shorter than in the type, more weakly wrinkled. Mesonotum and epinotal spines shorter, almost as in the var. *debilior* Forel. Color as in the type, only antennae and tarsi lighter brown.

*Type Locality:* Astrakhan.

Forel, who saw the type specimen, believed it to be a form of *rubra* s. lat., probably in the neighborhood of *r. rubra* and *sulcinodis*, rather than of *rugosa*. The status of this variety must await the discovery of males.

Dr. C. Menozzi had generously sent me the following descriptions of two new species from the Himalayas. The descriptions and comments are his.

### *Myrmica aimonis-sabaudiae* Menozzi, n. sp.

*Operaria:* Obscure brunneo-rufa, gaster niger, mandibulae, antennae et pedis brunnei. Caput opacum, profunde straito-rugosum, genis et occipite confuse reticulatis; clypei longitudinaliter striato, antice in lobum subacutum producto; mandibulis striatis, 8–10 dentatis; antennarum scapo basi curvato; flagellum clava 4-articulata. Thorax lateribus et mesonoto longitudinaliter rugosis; pronoto transversim rugoso, epinoti basi subtiliter striati, superficie declivi nitida, spinis gracilibus longissimis, suberectis; sutura promesonotali obsoleta, mesoepinotali impressa. Segmentum pediculi primum breviter petiolatum, nodo supra rotundato, secundum pyriforme, vel subconicum, latius quam longius, anco subtiliter punctato-striati. Pedes breviter oblique pilosi.

Long. mm. 5–5.5.

*Habitat.*—Karakorum (Himalaya).

Pour la constriction mésoépinotale très marqué cette nouvelle

*Myrmica* se rattache au groupe de *M. smythiesi* For. Est très semblable à *M. rugosa* Mayr mais avec le pétiole presque sessile et les articles 2-7 du funicule bien plus courts. Diffère de *M. smythiesi* par les épines plus longues et par la sculpture.

***Myrmica dicaporiacoi* Menozzi, n. sp.**

*Operaria*: Nigra, antennis, pedibus et gastri articulis postremis brunneo-rufescentibus, genibus, coxis et collo luteolis. Caput rugoso-striatum, spatiis inter rugas et strias punctulatis; dorsum et latera promesonoti rugosa; epinotum et pediculum punctulatis, gaster laevis et lucidus. Mandibulae vix striatae. Clypeus in *M. rugosa* Mayr elongatus, sed ossovius striatus et opacus. Scapus marginem occipitalem superans; primus et secundus funiculi articuli subaequales, 3-8 paulo longiores quam latiores; clava tribus articulis sistens. Oculi fortiter convexi et valde prominentis. Thorax sutura meso-epinotali vix conspicua, neso-pronotali obsoleta. Epinotum parte basalis quam declivi longiore, spinis brevibus apice vix incurvatis. Petiolum breviter pedunculatum, nodo parvo; postpetiolum antice et postice aequè angustatum.

Long. mm. 4.

*Habitat*.—Karakorum (Himalaya).

Du groupe *M. rugosa* Mayr; se distingue facilement par la sculpture, les épines courtes mais surtout par les yeux petits, assez convexes et beaucoup saillants en dehors des cotés de la tête.

***Myrmica tibetana* Mayr**

*M. tibetana*, Mayr, Hor. Soc. Ent. Rossicae, 1890, 24: 279, ♀; Emery, Deutsch. Ent. Zeitschr., 1908: 181-182, fig. 13, ♀; Ruzsky, Ann. Mus. Zool. Acad. Sc. Petrograd, 1915, 20: 440-1, fig. 21, ♀ ♂.

*Worker* (after Mayr and Emery): Length 3.2-3.5 mm.

Noteworthy for the compact habitus. Form of the head about as in *rubra*, except that the antennae are shorter, the segments before the 4-jointed club are as broad, or somewhat broader, than long. Thorax short and high, meso-epinotal impression strong; epinotal spines very short and broad at their bases, a little diverging. Petiole short and thick, with slightly concave anterior face. Postpetiole as broad as long.

Sculpturing of the head as in *laevinodis*; of the thorax, very fine, the surface dull or weakly shining, reticulate to reticulate-rugose; of the pedicel shining, slightly reticulate laterally, above smooth.

Pilosity much as in *laevinodis* but the erect hairs shorter; legs and antennae with copious, oblique and subappressed hairs, here and there with appressed pubescence.

Color light reddish brown, head and gaster brown.

*Male* (after Ruzsky): Length 4-4.9 mm.

According to Ruzsky's figure the antennal scape is subcylindrical, somewhat narrowed and a trifle bent at the base and is equal to the following 4-5 segments together. The antennal club is 5-jointed.

*Type Locality*: North Tibet: Jumel-Kuku Mt., April-June, 1884.

**Myrmica tibetana** subsp. **chinensis** Viehmeyer

*M. chinensis*, Viehmeyer, Archiv. f. Naturg., 1922, 88: 204, ♀ ♂.

*Female* (after Viehmeyer): Length 5 mm.

Distinguished from *tibetana* Mayr by the short, at the base gently curved, scape of the antenna and by the smooth part of the pedicel. Head somewhat shorter than in the worker of *tibetana*, the occipital margin a little more rounded, sides more even than in *laevinodis*, antennal scape not quite reaching the occipital margin (in the *tibetana* worker it surpasses by a trifle). Epinotal spines at least as long and quite similar to *laevinodis*, the space between them smooth and shining. Petiole, in profile, very sharply angular, postpetiole clearly transverse. Blackish brown to black, the legs more or less brown, the wings somewhat strongly smoky. Upright hairs yellowish, shorter than in *laevinodis*. Sculpturing very similar to that in *laevinodis*, barely weaker; eyes, however, less projecting and the petiole more or less sculptured.

*Male* (after Viehmeyer): Length 3.5 mm.

Head dull, extremely finely reticulate, the upper surface of the mandibles longitudinally rugose. Antennal scape exceeding the occipital margin a good deal, at the base weakly bent, the club clearly 5-jointed, differing from Ruzsky's illustration of the *tibetana* ♂ in being more slender. Epinotal angles sharper than in *laevinodis*, but without teeth. Thorax finely and longitudinally rugulose, but shining; the remainder of the body strongly shining. Only the legs with shorter, appressed pubescence. Color black, legs brownish black, wings as in the female.

*Type Locality*: China: Szechwan Province: Sungpanting (Stötzner Expedition of 1914).

"Perhaps only a form of *tibetana* and near its variety *furva* Ruzsky."

**Myrmica tibetana** var. **furva** Ruzsky

*M. tibetana* var. *furva*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 440-441, ♀.

*Worker* (after Ruzsky):

Differs from the typical form in deeper sculpture and darker color.

*Type Locality*: Tibet: Yangtse River region, 12,-12,500 feet, March, May, 1901 (Kozlov).

**Myrmica commarginata** Ruzsky

*M. commarginata*, Ruzsky, Formic. Imp. Rossici, 1905: 708-709, ♀.

*Worker* (after Ruzsky and Emery): Length 3.7 mm.

Dark reddish brown, antennae and legs lighter, head and gaster dorsally blackish brown. Head and thorax dull, coarsely wrinkled; declivous surface of epinotum between the spines smooth; nodes of the pedicel somewhat shining and finely wrinkled; gaster smooth. Head long with rounded occipital margin; eyes situated a little before the middle of the sides of the head; frontal area smooth; mandibles longitudinally striate, with 6 teeth; scape at the base bent in a curve, funiculus with 4-jointed club. Mesoepinotal impression small, not deep. The mesoepinotal region strongly compressed and, on either side, dorsally

with a carina which extends from the pronotum to the base of the spines. Epinotal spines not longer than half the basal surface (declivity ventral to them), diverging and broad at the base and somewhat laterally compressed, the apices somewhat curved. Petiole short, anterior face forming an angle with the dorsal, very weakly convex, surface, without a cylindrical peduncle. Postpetiole somewhat higher than the petiole, broader and of similar form. Upright hairs somewhat thick on the head and gaster, thinner on the thorax and pedicel, legs shining, with sparse, thin, reclining hairs.

*Type Locality*: Transbaikal: Tabajkal region, 27.VII.1901.

"This species is very distinct in the lateral carinae and narrowness of the thorax."

### *Myrmica inezae* Forel

*M. inezae*, Forel, Rev. Suisse Zool., 1902, 10: 226, ♀.

*Worker* (after Forel): Length 5.2 mm.

Black. Legs, antennae, mandibles and apex of gaster russet-brown. Pilosity moderately erect, yellowish red, oblique, short and very abundant on the tibiae and scapes. Gaster, frontal area and epinotal declivity smooth. Legs and scapes reticulate and subopaque, the scapes also wrinkled. All the rest (including the mandibles) grossly wrinkled, rough between the wrinkles, the pedicel more feebly sculptured. The ridges are longitudinal on the head, *transverse* on the pronotum, the mesonotum and between the spines, irregular on the margins and on the metanotum. Mesoepinotal impression feeble. Epinotal spines subvertical, inclined backwards, a little longer than in *M. rugosa* (where they are subhorizontal), almost as long as the basal face. The petiole with a long, slender pedicel, much longer than the node, which is more subcubic, broader at the summit than in *rugosa* (less cuneiform). Postpetiole as in *rugosa*. Otherwise as in *rugosa*. Not the metasternal spines.

"A single worker from Pachmarhi (Schurr). Much different from *ritae* and *margaritae*, which have the metasternal and epinotal spines much longer; this species is distinguished from *rugosa* by the petiole, the transverse wrinkling and its subvertical spines."

### *Myrmica pachei* Forel

*M. pachei*, Forel, Bull. Soc. Vaud. Sc. Nat., 1906, 42: 79-82, ♀ ♀ ♂.

*Worker* (Cotype): Length 5-5.5 mm. (after Forel).

Head, between the eyes, 0.6 as broad as long (with mandibles), anterior clypeal margin convex, eyes, in breadth, twice the diameter of the distal end of the antennal scape; scapes surpassing the posterior margin of head by  $\frac{1}{6}$  their length, seen from behind, in a drawn-out sigmoid curve, bent at basal  $\frac{1}{4}$  and close to distal end, proximal diameter  $\frac{1}{2}$  that of distal end; antennal club 4-jointed, joints 1-2 of the funiculus together as long as joints 3-5 together. Thorax, in profile, unusually convex to the moderately impressed mesoepinotal impression; epinotal spines slender, straight, projected backwards and upwards at slightly less than 40 degrees, slightly shorter than the declivity ventral to



them; from above, diverging, over  $1\frac{1}{2}$  times as long as the distance between their bases. Petiole, in profile, stout, anterior face slightly concave, dorsal surface evenly convex, distinctly longer from apex of ventral tooth to postpetiole than high. Postpetiole, in profile, distinctly higher than the petiole or than it is long, dorsal surface highly convex, ventral surface nearly plane, produced anteriorly in an acute small lobe. Gaster ovate. Legs moderately long and slender.

Surface of head shining, finely and evenly rugulose, densely punctate between; mandibles rugulose; clypeus shining, sparsely rugulose, punctate; frontal area smooth and shining. Dorsal surface of thorax *transversely* and densely rugulose, lateral surfaces rugulose, longitudinally basally, more vertical dorsally, anterior part thickly punctate. Pedicel finely reticulate-punctate with a few marginal, scattered and feeble rugae. Gaster smooth and shining. Legs and antennae finely striate.

Pilosity sparse, fine and acute; subappressed hairs on the appendages; antennal club pubescent.

Color dark brown, appendages hardly lightly, gaster piceous.

*Female* (after Forel): Length 5.6–5.8 mm.

Thorax narrower than the head. Longitudinal striae on the mesonotum; epistome more rugose. Wings brown, with the cubital cell divided into thirds by the intersection of a vein, as in the other species of the genus. Otherwise as in the worker, and hardly larger.

*Male* (after Forel): Length 5–5.7 mm.

Mandibles triangular, feebly sculptured, armed with about 6 teeth. Head slightly trapeziform, larger posteriorly than anteriorly, at the posterior margin slightly, and at the other margins more strongly, convex. Eyes nearly at the anterior third. The scapes, bent towards their base, surpassing the occiput by about  $\frac{1}{6}$  of their length. Second joint of the funicle distinctly longer than the first and the third. The metanotum armed with two triangular teeth. Petiole very convex dorsally, as long as broad.

Epistome transversely striate only on its anterior  $\frac{2}{3}$ , smooth and convex behind. Frontal area smooth. Head striate as in the worker, but more strongly reticulate and dull to nearly dull. The striae in the middle of the front are compact, converging to a point, the extremity of the frontal area, and describing an elliptically convex bend about the frontal groove. They run from the front of the margin to the frontal area and diverge simply anteriorly. The head is sprinkled with punctations at the base of the striae. Sculpture of the thorax as in the female, but feebler. Posterior half of the metanotum smooth. Pedicel subopaque, finely reticulate, likewise the legs and scapes.

Color, pilosity and wings as in the female, but the teeth of the metanotum are black and the legs almost black. Wings less brown (more clear).

*Type Locality*: N. E. Nepal: Tersam, 3,600 meters (Pachei); from a colony in a tree trunk.

The fine sculpturing and especially the transversely and finely rugulose sculpturing of the thorax distinguish this *Myrmica* from all other known species.

*Myrmica kurokii* Forel

*M. rubra* v. *kurokii*, Forel, Mitt. Naturh. Mus. Hamburg, 1907, 24: 18, ♀.

*Worker* (after Forel): Length 5–5.2 mm.

Mandibles striate, with more or less curved, nearly even, outer border and 7 teeth. Clypeus strongly curved anteriorly as in the European *rubra*, but less than in *M. rugosa* Mayr. Frontal area smooth. Base of the scape somewhat roughly bowed as in *ruginodis* Nyl., but not as roughly as in *sulcinodis*; club 4-jointed (Emery). Head right-angled, with very clear, but only slightly indicated median impression. Scape exceeding the occipital margin a little. Thorax similar to that of *ruginodis* and especially similar to the form which Ruzsky has called *rugosa* var. *kirgisica*, and which by no means belongs to *rugosa*, but to *rubra*, in the neighborhood of *ruginodis* and *sulcinodis*, however, the mesoepinotal impression is shallower and broader. The petiole is very short, not as short and thick as in *brevinodis* Emery, but, however, cuboidal, with a rounded, broad upper surface and not a blunt edge as in *kirgisica*. Postpetiole flatter than in *sulcinodis* (Emery). The spines are also much longer than in *kirgisica*, somewhat as in *sulcinodis* and somewhat deflected. 3–6 funicular segments somewhat broader than long.

Somewhat less coarsely rugose longitudinally than in *kirgisica* and *sulcinodis*, but coarser than in *ruginodis*. Metanotum smooth between the spines. Pedicel coarsely rugose. Abdomen smooth (short and finely striate at the base—Emery). Uneven between the rugosities, therefore little shining. Legs and antennal scape only with thick, somewhat fine, appressed hairs. Body with scattered yellow upright hairs.

Head and gaster brown, the latter dark brown; the remainder reddish brown.

“Differing from *kirgisica* in the petiole and the much more strongly curved clypeus. Through the much longer spines and the broader, even occipital margin, likewise clearly differentiated from the other subspecies.”

*Type Locality*: Japan (ex. coll. Frühstorfer).

Three workers from the Southern Japanese Alps (H. Yoshioka coll.) appear referable to this species although larger (5.3–6.1 mm.) and with the frontal area distinctly, though finely, striate. The head is about 0.67 as broad between the eyes as long (with mandibles). This is a very distinct species.

*Myrmica kurokii* subsp. *helleri* Viehmeyer

*M. helleri*, Viehmeyer, Arch. f. Naturg., 1922, 88: 204–205, ♀.

*Worker* (after Viehmeyer): Length 5.5 mm.

“Nearest to *M. kurokii* Forel of Japan; differing clearly from it, however, in the essentially stronger sculpturing.”

Blackish brown, the legs a little lighter. Anterior part of the body, including the frontal area and the declivous surface between the epinotal spines, dull. Head somewhat coarsely and longitudinally, thorax con-

fusedly, pedicel, especially the postpetiole, somewhat finely, rugose; interrugally with extremely fine reticulations, laterally and posteriorly on the head, between the rugosities, with shallow pits. Head somewhat broader and shorter than in *kurokii*, with even sides and the occipital corners more distinct than in *sulcinodis*. Antennal scape as in *rubra*, at the base broadly and weakly bowed; club 4-jointed, the anterior ("vorderen") joints somewhat shorter than in *kurokii*. The pedicel similar in profile, but the weakly concave anterior surface of the petiole is somewhat longer and the dorsal surface slopes more strongly away from the angle. Postpetiole more weakly trans-verse. Otherwise entirely as in *kurokii*. "Perhaps only a form of it."

*Type Locality*: China: Szechwan Province: Kwansien (Stötzner Expedition of 1914).

***Myrmica kurokii* subsp. *sontica* Santschi**

*M. kurokii* v. *sontica*, Santschi, Bull. Ann. Soc. Ent. Belg., 1937, 77: 367, ♀.

*Worker* (after Santschi): Length 5–5.5 mm.

More elongated petiole than in *kurokii*; basal face of epinotum between the spines reticulate in the large and medium individuals, more feebly and more longitudinally sculptured in the small; petiole reticulate-punctate, postpetiole more shining, with the ridges elongate; gaster shining with short basal striae; dark brown, sides and sterna paler, appendages russet and brighter.

*Type Locality*: Japan: Yamakita (C. Teranishi).

***Myrmica kurokii* subsp. *tipuna* Santschi**

*M. kurokii* st. *tipuna*, Santschi, Bull. Ann. Soc. Ent. Belg., 1937, 77: 367–368, ♀.

*Worker* (after Santschi): Length not given but presumably as in *sontica*.

Distinguished from *sontica* chiefly by the more feeble sculpture of the pedicel and the more "claire" color of the abdomen. Mandibles 7–8-toothed, apical very long, striate; scape bowed and slender as in *rubra*; eyes and antennae also as in *rubra*; epinotal spines fine, as long as the interval between their apices but a little shorter than in *rubra*; the petiole as in *rubra* or a little larger, the anterior pedicel longer as in *kurokii*. Evidently a form based chiefly on sculpture and color.

*Type Locality*: Formosa (K. Sato).

***Myrmica kozlovi* Ruzsky**

*M. kozlovi*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915: 435–436, figs. 10–11, ♀.

*Worker* (after Ruzsky): Length 5–6 mm.

Head short, rounded posteriorly, clypeus convex, anterior margin rounded, frontal carinae small; antennal scape extending to the thorax, bent evenly at the base, antennal funiculus 4-jointed. Promesonotum feebly convex, metanotum flat dorsally, mesoepinotal impression feeble; epinotal spines well developed, broad at the base, produced backwards, feebly divergent, with the apices sometimes a little deflected. Pedicel short as in *M. sulcinodis*; petiole much shortened and with a short,

thick peduncle, anterior face feebly concave, dorsal and posterior surfaces convex. Postpetiole dorsally convex, ventral surface nearly plane.

Sculpturing of the body rough and rugose as in *M. rugosa*; clypeus with irregular rugae, smooth and shining interrugally and at the posterior margin adjacent to the smooth and shining frontal area; head dorsally with longitudinal rugae, laterally irregularly rugose and punctate. Thorax rugae, laterally irregularly rugose and punctate. Thorax coarsely and irregularly sculptured, punctate; only on the sides posterior to the prothorax is the sculpturing longitudinally rugose; bases of epinotal spines with fine longitudinal rugae. Pedicel less sculptured than the thorax, petiole with larger and more irregular rugae than the postpetiole, which is sulcate dorsally. Head, thorax and pedicel entirely dull, gaster smooth and shining with fine striae.

Gaster covered with yellowish hairs, legs with dense reddish hairs.

Color of body brownish black to black, legs, antennae and mandibles brown, tarsi lighter.

*Type Locality*: Eastern Tibet: Basin of the Yangtse River, 12,500–13,000 feet (Kozlov), March and May, 1901.

"This is a mountainous form between *M. rugosa* Mayr, *M. sulcinodis* Nyl. and *M. kurokii* Forel."

#### *Myrmica kozlovi* subsp. *mekongi* Ruzsky

*M. kozlovi* subsp. *mekongi*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 437, fig. 12, ♂.

*Worker* (after Ruzsky):

Differing from the typical form in shorter and more erect epinotal spines, feebler sculpture and lighter coloration.

*Type Locality*: Tibet: Bar-chu River, Mekong basin, 12,000 feet, Sept. 1900 (Kozlov).

#### *Myrmica kozlovi* subsp. *ruzskyi* nomen novum

*M. kozlovi* subsp. *subalpina*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 438, fig. 14, ♂.

(nec *M. rubra brevinodis* var. *subalpina* Wheeler, Bull. Wisconsin Nat. Hist. Soc., 1907, 5: 77, ♂.)

*Worker* (after Ruzsky):

Distinguished by the stout epinotal spines which are wide at the base, sharply curved in the middle and projected almost horizontally back; from above subparallel. These are longer than in *mekongi*.

Rugosity of head and thorax as in *subbrevispinosa*, color darker, otherwise much as in the above mentioned subspecies.

*Type Locality*: Eastern Tibet: Valley of the Yangtse, March, 1901 (Kozlov).

Ruzsky believed that this ant had such unique epinotal spines as to rank possibly as a distinct species. While Ruzsky labels his original figure as "*Myrm. kozlovi subbrevispinosa*, var. *subalpina*," and Emery followed him in the Genera Insectorum, his original description is headed "*Myrm. kozlovi*, subsp. *subalpina* subsp. nova."

**Myrmica kozlovi** subsp. **subbrevispinosa** Ruzsky

*M. kozlovi* subsp. *subbrevispinosa*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 437, fig. 12, ♀.

*Worker* (after Ruzsky): Length 5 mm.

Differs from the typical form and from *mekongi* in the form of the epinotal spines. These are short, thickened, and directed almost straight backwards.

*Type Locality*: Tibet: Yangtse Basin, March, 1901, (Kozlov).

**Myrmica bergi** Ruzsky

*M. bergi* Ruzsky, Zool. Jahrb. Syst., 1902, 17: 473, ♀; Ruzsky, Formic. Imp. Rossici, 1905: 675-678, figs. 167, 168, ♀ ♂; Kuznetzov-Ugamskij, Zool. Anz., 1929, 83: 44-45, map.

*Worker* (Cotype): Length 4.6 mm. (4.5-5.5 mm., after Ruzsky).

Head 0.64 as broad between the eyes as long (with mandibles), occipital margin straight, occipital corners evenly rounded, eyes slightly closer to the anterior clypeal than to the occipital margin; anterior clypeal margin transverse. Antennal scape slightly exceeding the occipital margin, seen from a posterior view, bent at about the basal  $\frac{1}{5}$  in a rounded angle of about 30 degrees; joints 1 and 2 of the funiculus together about as long as joints 3-5 together, all joints longer than broad, club 4-jointed. Thorax, in profile, very evenly convex to the feeble and broad mesoepinotal impression; epinotal spines acutely pointed, straight, projected backwards and upwards at about 45 degrees, shorter than the declivity ventral to them; spines, from above, a little longer than the distance between their bases, slightly diverging. Petiole, in profile, short, peduncular margins converging anteriorly, anterior face slightly concave, a little shorter, from apex of ventral tooth to postpetiole, than it is high. Postpetiole, in profile, distinctly higher than the petiole and than it is long, dorsal margin convex and produced posteriorly, ventral margin convex and produced anteriorly. Gaster sub-elliptical. Legs of moderate length.

Surface of head shallowly sculptured; median dorsal surface, including clypeus, finely and closely rugulose, sides rugulose-reticulate, densely and conspicuously punctate between the sculpturing, frontal area clearly indicated, striate at the posterior margins, smooth and shining anteriorly. Dorsal surface of thorax irregularly sculptured with a general longitudinally rugose tendency, mesonotum with several nearly smooth areas, infraspinal surface of epinotum with fine transverse striae; sides of thorax longitudinally rugose; interrugal surfaces densely punctate, especially on the sides. Petiole rugose-punctate; postpetiole more shallowly rugose-punctate with a finely striate-punctate longitudinal area on the dorsal surface. Thorax smooth and shining. Antennal scapes finely striate; legs shining, indistinctly sculptured.

Pilosity moderately sparse, hairs of body, including those of dorsal thoracic surface, acute and moderately fine; moderately abundant and reclining on the appendages; antennal club with appressed pubescence.

Color of body reddish brown, slightly darker dorsally and with gaster dark brown; appendages reddish brown.

*Female* (after Ruzsky and Emery): Length 5.5-6.5 mm.

Color, sculpturing and pilosity about as in the worker; epinotal spines broad at the base, almost straight, pointed.

*Male* (after Ruzsky and Emery): Length 5 mm.

Clypeus and frontal area shining; head and thorax dorsally wrinkled; nodes of the pedicel shining. Scape about as long as  $\frac{1}{3}$  the funiculus or a little shorter than the 4 following joints; club 4-jointed. Epinotum with rounded gibbosities. Posterior femora not clearly incrassate in the middle. Pilosity of the tibiae about as in *sulcinodis*. Castaneous brown, darker dorsally. Wings dark.

*Type Localities*: Turkistan: Tas-Bulak, west coast of the Aral Sea; mouth of the Syr-Daja; Ack-Dshalpas, north shore of the Aral Sea (H. L. S. Berg, 1900-1).

Turkistan: Gschimkent (Cimkent), South Kazakstan, Kirgisen Steppe, Turkmenistan (N. N. Kuznetzov-Ugamskij). Transcaucasia.

Ruzsky and Emery placed this species next to *sulcinodis* Nylander because of the form of the worker antennal scape. The short antennal scapes of the male and the short epinotal spines and fineness of sculpturing of the worker, however, lead me to believe its affinities are more with *M. brevinodis* Emery. Genitalic slides of the males would quickly settle this point.

Kuznetzov-Ugamskij (1929) gives a map showing the geographical distribution of this species. It is found in large, but isolated, areas between the Caspian Sea and Lake Balkash.

#### *Myrmica bergi* var. *barchanica* Ruzsky

*M. bergi* var. *barchanica*, Ruzsky, Formic. Imp. Rossici, 1905: 678, ♀.

*Worker* (after Ruzsky): Length 4.5-5.2 mm.

Sides of the head with stronger and thicker reticulations. Almost without upright hairs (there are, however, only isolated upright hairs on the anterior dorsal surface of the thorax, on the petiole and on the base of the gaster); on the head are groups of very thin and short hairs; the antennal scape almost lacks hairs. The wrinkles on the thorax are fewer, more or less regular. Sculpturing of the petiole is weaker. Color lighter than in *bergi*, similar to *stangeana*. Legs lighter than the thorax, yellow reddish-brown. Base of the gaster lighter than the other parts.

*Type Locality*: Astrakhan: Khauskaja Stavka (early June, 1902) (Ruzsky).

"Living in the midst of a rather luxuriant flora (mainly Linden trees and others). Nests in holes in the ground. I took it also on plants."

#### *Myrmica bergi* var. *divergens* Karawajew

*M. bergi* var. *divergens*, Karawajew, Zool. Anz., 1931, 94: 105, fig. 1, ♀.

*Worker* (after Karawajew): Length 4.5 mm.

Differs from the typical form as follows: The rugosities from the margins of the frontal area diverge in parallel and straight lines to the (occipital) angles (in the typical form they diverge in a fan-shaped area to the outer corners). The anterior margins of the frontal carinae are clearly rounded (in the typical form—I compare with an example at hand from Tshimkent, Turkmenistan, N. Kuznetzov, 18.VII.23—they

are more pointed). Anterior face of the petiole sloping evenly; in the above mentioned example it forms a weak concavity. In other respects similar to the typical form.

*Type Locality*: Insel Char-jalach, 50 km. below Olekminsk, 11.6.1925 (L. Bianchi).

This variety was described from one specimen.

***Myrmica bergi* subsp. *persiana*, nomen novum**

*M. bergi* var. *fortior*, Crawley, Ent. Record, 1920, 32: 163, ♀.  
(nec *M. smythiesi* var. *fortior* Forel, Rev. Suisse Zool. 1904, 12: 22-23, ♀.)

*Worker* (after Crawley): Length 5.0 mm.

"Head broader than in *bergi*, the sculpture of the head and thorax coarser and more broken and that of the nodes much coarser than in the type. Entire body darker than in *bergi*: in all other respects similar to *bergi*."

*Type Locality*: Iran (N. W. Persia): Enzeli (P. A. Buxton, 1919).

In Dr. Wheeler's collection is what appears to be a cotype with the above locality label. The head is 0.67 as broad between the eyes as long (with mandibles), the mesoepinotal suture is deeper than that of the *bergi* cotype, the sculpturing is coarser and the color is darker. The Kazakhstan specimens listed under *bergi* are intermediate between this variety and the typical form.

***Myrmica bergi* subsp. *kamyschiensis* Arnoldi**

*M. bergi kamyschiensis* Arnoldi, Folia Zool. et Hydrobiol., Riga, 1934, 6: 159, ♀.

A form from Transcaucasia unknown to me.

THE INSECT CRANIUM AND THE "EPICRANIAL SUTURE," by R. E. SNODGRASS. 52 pages, 15 figures. Smithsonian Miscellaneous Collections, Vol. 107, No. 7, 1947.

One can hardly claim to be an entomologist if he must acknowledge ignorance of the author's dominant position in the study of insect morphology, hence it is almost superfluous to comment on the high quality and significance of this contribution.

The study stems from an article by Du Porte (1946) which asserts that the epicranial suture "has no structural significance at all, being merely a line of weakness in the head wall where the cuticle splits at ecdysis, with its arms taking quite different courses in different insects," and that muscle attachments are not dependable criteria for the determination of skeletal homologies. According to Snodgrass' introduction the first idea had already been developed in his manuscript but he disagrees with the second and introduces the relations of the nervous system as an additional factor in the problem.

Data are presented on the "ecdysial cleavage line of the head" in Apterygota and fourteen orders of Pterygota, illustrated with great clarity in the series of text figures. In conclusion the author states that the "insect cranium is *not* composed of 'plates' united by 'sutures,'" but he finds a definite relationship between the position of the epicranial suture and the muscle attachments in the head. The term frons assumes an indefinite anatomical significance and the facial apotome is shown to vary according to the extent of the arms of the suture, in some cases including the median part of the frons and in some an additional median part of the clypeus.

The article concludes with a bibliography of fifty-four titles.—A. W. L.

# THE RELATION BETWEEN POISON CONCENTRATION AND SURVIVAL TIME OF ROACHES INJECTED WITH SODIUM AND POTASSIUM CYANIDES AND POTASSIUM FERRICYANIDE

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In preceding papers (3, 4, 5) the authors described and analyzed concentration-survival time curves pertaining to roaches injected with arsenicals. The present paper is a study of the relationship between concentration of poison and survival time of large nymphs of the American roach (*Periplaneta americana* (L.)) injected quantitatively with sodium cyanide (NaCN) (experiments 1 A, 1 B, 1 C), potassium cyanide (KCN) (experiment 2), and potassium ferricyanide ( $K_3Fe(CN)_6$ ) (experiment 3).

## METHODS

The NaCN and KCN were dried in a calcium chloride desiccator. Each NaCN, KCN, and  $K_3Fe(CN)_6$  solution was prepared shortly before being used. Injections of the NaCN solutions were performed in the way described previously (4). The KCN and  $K_3Fe(CN)_6$  solutions were injected in the same way except that the solutions were drawn into and forced out of the injection pipette by the pressure of a screw on a rubber bulb attached to the pipette, instead of by the use of a mouthpiece. Insects which bled during or just after injection were replaced by others injected successfully. When the higher concentrations of the potassium salts were injected, replacements because of hemorrhage were frequent and there was considerable uncertainty as to whether later on some of the successfully injected insects might have bled slightly. Because of these difficulties the number of insects used to determine a point on the KCN or the  $K_3Fe(CN)_6$  curve was not always the same. After the insects were injected they were kept in vials, as described previously (4), at a temperature of 80°–85° C. and a relative humidity of 40–80 per cent, and were examined periodically for symptoms of poisoning and death.

Since in these experiments each insect received 0.020 ml. of a molar solution of poison per gram of body weight, a *stated* molar concentration is *twice* the molar concentration actually injected; this facilitates the comparison of these with other results for insects injected with 0.010 ml. per gram of body weight of molar concentrations of other poisons. The stated concentrations were used in calculating survival times.

The times of appearance of certain symptomatic stages, symbolized by A, A—, S, L, M<sub>1</sub>, M<sub>2</sub>, and D as described previously (3), were recorded during these experiments. The symptomatic picture of these cyanide-poisoned roaches was compared with that of the arsenic-poisoned roaches by the graphical method already described (3). During arsenical poisoning the symptoms A to D were progressive from



A, which represents an apparently normal condition, to D, representing death. The development of symptoms in arsenical poisoning is used as a standard of reference. A change in the opposite direction, as from  $M_1$  or  $M_2$  toward A, exhibited by many of the cyanide-poisoned roaches, represents partial or complete recovery. In this paper, the number of minutes from the time of injection to the time at which an insect recovered from D (narcosis) to a given symptomatic stage is referred to as the recovery time.

#### RESULTS AND DISCUSSION

The relationship between concentration and survival time may be interpreted more readily if first the symptomatic picture of the roaches injected with the different concentrations of these cyanides is considered. In general, as will be shown, each of these poisons can produce two effects in an injected insect, a narcotic and a lethal

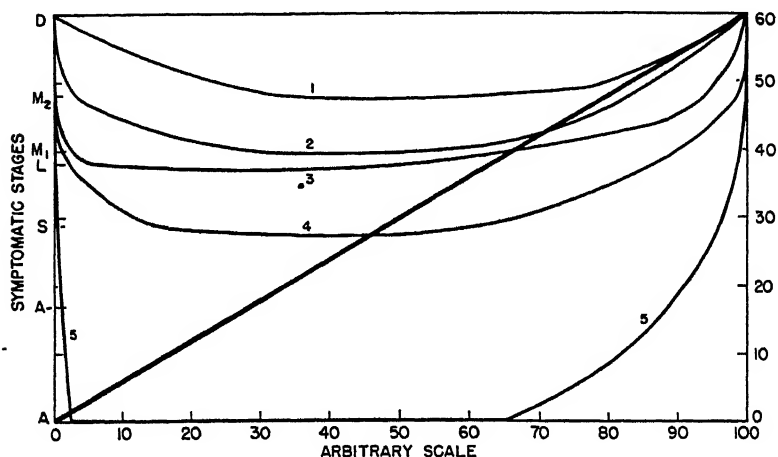


FIG. 1. Development of symptomatic stages A, A-, S, L,  $M_1$ ,  $M_2$  and D by roach nymphs injected with sodium cyanide (curves 1-5), compared with that of nymphs injected with sodium metarsenite (diagonal straight line). The numerical values of the symptomatic stages are on the vertical axis to the right. Curves 1, 2, 3, 4, and 5 refer, respectively, to the concentrations 0.2040, 0.1224, 0.08160, 0.07140, and 0.04080.

effect. Complete narcosis is indicated by the failure of an insect to respond to mechanical stimulation. As permanent inability to respond to mechanical stimulation was used as a criterion for death, it was not certain whether an insect permanently inactivated by one of the poisons was narcotized or dead, until putrefaction had set in or some other sign of death had appeared.

In figure 1 the symptomatic picture exhibited by roaches poisoned with NaCN is compared, by the graphical method described earlier, with that reported previously for roaches poisoned with sodium metarsenite. Whereas, once symptoms appeared, the arsenite-poisoned roaches progressed continuously along the diagonal straight line from A to D and usually without any recovery, the roaches injected with

certain concentrations of KCN passed very rapidly from A to D (narcotic effect). After this they showed partial or complete recovery, depending upon the dose of poison, and passed along the curved lines to D as the lethal effects of the poison took place. When the injected

TABLE I

ARITHMETIC MEANS OF RECOVERY TIMES OF ROACHES INJECTED WITH NaCN OR KCN

CONCENTRATION (molar)	MINUTES TO RECOVER TO—				
	M <sub>2</sub>	M <sub>1</sub>	L	S	A
	Experiment 1 C (NaCN)				
0.3060.....	1203+	.....	.....	.....	.....
.2550.....	799+	.....	.....	.....	.....
.2040.....	571	.....	.....	.....	.....
.1632.....	212	.....	.....	.....	.....
.1428.....	351	.....	.....	.....	.....
.1326.....	273	796+	.....	.....	.....
.1224.....	144	1443	.....	.....	.....
.1122.....	116	510	.....	.....	.....
.1020.....	128	507	.....	.....	.....
.09180.....	84	505	2338+	.....	.....
.08160.....	41	208	636	7630+	.....
.07140.....	52	294	1000	3838	.....
.06120.....	22	107	211	373	2885
.04080.....	2	49	108	143	1228
.03060.....	0.5±	35	80	104	500
.02040.....	0.5±	13	37	50	90
.01020.....	0.5±	5	15	28	71
.00510.....	0.5±	7	8	25	68
Controls.....	.....	.....	.....	.....	.....
	Experiment 2 (KCN)				
0.2304.....	685+	.....	.....	.....	.....
.1935.....	352+	.....	.....	.....	.....
.1536.....	232+	368+	.....	.....	.....
.1229.....	95	441+	.....	.....	.....
.09830.....	7	188	322	421+	577+
.07680.....	5	70	240	460+	629+
.05760.....	7	73	250	682+	1640+
.03840.....	4	21	98	287	591
.01920.....	.....	9	41	160	268
.007680.....	2	6	7	15	27
Controls.....	.....	.....	.....	.....	.....

concentration was sufficiently high, the insects passed rapidly to D and thereafter showed no recovery. For such insects death took place before any detectable recovery from the narcotic effect was possible, and the end point D probably represented complete inactivation due

to narcosis rather than death. When the injected concentration was sufficiently low, inactivation by narcosis was not complete and was of short duration. Curves 1 to 5 illustrate the different extents of recovery from the narcotic effects of different concentrations of poison and the subsequent approach to D, representing death. The arbitrary value on the horizontal axis is converted to observed recovery time in minutes when multiplied by the appropriate factor: curve 1, 17.25; curve 2, 47.28; curve 3, 104.1; curve 4, 323.5; curve 5, 500.0.

The symptomatic picture of KCN is about the same as that for NaCN and, therefore, is represented approximately by Figure 1. The symptomatic picture for  $K_3Fe(CN)_6$  seemed to be similar, but complete observations of symptoms were not made in experiment 3. The recovery times are shown in Table I for NaCN and KCN.

The injection into a roach of one of these three cyanide poisons usually was followed by a marked increase in bodily activity accompanied by violent tremors, particularly noticeable in the appendages. Tremors were produced by the sublethal as well as by the higher concentrations. The activity and tremors were most marked during the initial rapid passage from A toward  $M_2$  or D.

None of the roaches injected with NaCN showed any recovery at concentrations higher than about 0.4 M, Table II and Figure 2, and most roaches showed no recovery at 0.3060 M. It is very likely that they were permanently inactivated by the narcotic effect of the poison and died later while still narcotized. The reasons for this opinion are (1) that the insects did not have the appearance of insects known to be dead, (2) that insects inactivated by the high concentrations of the poison did not putrefy as soon as they were expected to, (3) that at certain concentrations some insects of a group showed partial recovery whereas the others did not, and finally (4) that in experiment 2 (KCN) many of the insects, including some of the controls, developed a red color about 6 hours after they were known to have died, whereas the insects inactivated by high concentrations of the poison developed the red color much longer after becoming inactivated. The approximate times to appearance of the red color are included in Table III; these times minus 360 minutes offer a very rough basis for estimating real survival times.

Previous work (3, 4) showed that a complete concentration-survival time curve for roaches injected with an arsenical possessed a critical zone. The critical zone is a portion of the concentration range within which the groups of insects used to determine a point on the curve tend to form a bimodal frequency distribution with respect to survival time, or to form two separate distributions. Within the critical zone the different measures of central tendency fail to agree well in value. Each cyanide concentration-survival time curve described in this paper has two critical zones, one for the narcotic and one for the lethal effect, the latter corresponding to the critical zone of the arsenical curves. A critical zone for narcosis was not evident for the times of appearance of red color. Within these two critical zones it has not been possible to obtain satisfactory mean values for the survival times. This has been a serious interference with the obtaining of good fits to the experimental data through the use of the equations developed previously (4).

The obtaining of close fits to the observed data is rendered difficult also by the fact that, whereas the survival-time curves for arsenicals are death curves throughout, these cyanide curves are composite. Apparently they are narcosis curves for the upper lethal concentrations,

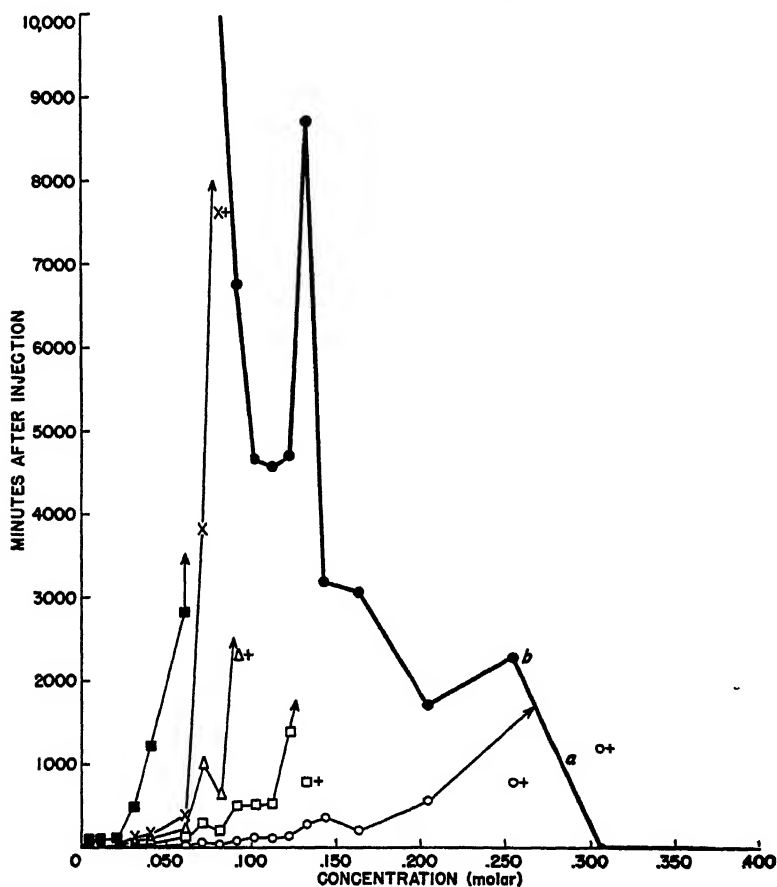


FIG. 2. Part of a concentration-survival time curve (solid dots) for nymphs injected with NaCN (experiment 1, C). Recovery curves also are shown (■, ×, △, □, and ○, represent A, S, L, M<sub>1</sub>, M<sub>2</sub>, respectively). Survival time and recovery time in minutes are on the vertical axis. A vertical distance between two recovery curves represents the time an insect was in the symptomatic stage represented by the lower curve. Each survival time is the arithmetic mean of the larger of the subgroups in a bimodal frequency distribution in a critical zone.

transitional at intermediate concentrations, and death curves only for the lower lethal concentrations of injected poison.

Tables II and III show the arithmetic and harmonic means of survival times for each group of insects injected with a given concentration of poison. Corresponding values for the larger subgroup

TABLE II  
OBSERVED SURVIVAL TIMES OF ROACHES INJECTED WITH SODIUM CYANIDE. THE VALUES INDICATED BY ASTERISKS  
ARE PLOTTED IN FIGURE 2

CONCENTRATION (molar)	EXPERIMENT 1 A				EXPERIMENT 1 B				EXPERIMENT 1 C			
	SURVIVAL TIME (minutes)			Number of Insects	SURVIVAL TIME (minutes)			Number of Insects	SURVIVAL TIME (minutes)			Number of Insects
	Median	Arithmetic Mean	Harmonic Mean		Median	Arithmetic Mean	Harmonic Mean		Median	Arithmetic Mean	Harmonic Mean	
0.8160	5	5	5	10	5	5	5	10	5	5	5	20
.6120	5	5	5	10	5	5	5	10	5	5	5	20
.4080	5	290	(5)	10	5	5	5	10	5	199	(6)	20
.3060	(5)	(5)	(5)	7	...	...	...	...	5	834	(5)	17
	...	...	...	...	...	...	...	...	5	5	5	10
.2550	...	...	...	...	...	...	...	...	(5)	(5)*	(5)	7
	...	...	...	...	...	...	...	...	2160	1840	13	10
.2040	472	832	7	10	2197	3440	18	10	(2160)	(2289)*	(1579)	8
	(667)	(1039)	(644)	8	(2198)	(2410)	(1137)	8	805	2136	5	20
.1632	1193	1545	15	10	3375	4312	2019	10	(1188)	(1725)*	(723)	16
	(1310)	(1716)	(1253)	9	...	...	...	...	1515	2629	29	20
.1428	...	...	...	...	2315	2920	1382	10	(1710)	(3083)*	(1565)	19
	...	...	...	...	(2320)	(3214)	(2540)	9	2315	2620	1382	10
.1328	...	...	...	...	10800	19008	10193	10	10800	19008	10193	9
	...	...	...	...	(3960)	(8743)	(7881)	7	(9860)	(8743)*	(7881)	10
.1224	4560	4087	3527	10	6480	10760	5160	10	5040	7423	4046	7
	...	...	...	...	(4320)	(5530)	(4267)	8	(4560)	(4728)*	(3709)	20
.1122	...	...	...	...	5040	13692	4468	10	5040	13692	4468	18
	...	...	...	...	(5040)	(4594)	(3237)	7	5040	(4594)*	(3237)	10
.1020	2263	3380	1983	10	7920	10800	5379	10	4320	7040	2898	7
	(2262)	(3552)	(2452)	9	(5040)	(5940)	(4517)	8	(3600)	(4882)*	(3124)	20
.09180	5760	12959	4141	10	14400	20560	6174	10	9360	16754	4957	17
	(3600)	(4236)	(3012)	7	(10800)	(9360)	(6572)	7	(4320)	(6768)*	(4410)	20
.08160	18720	25448	6565	10	14760	20232	10901	10	16560	22860	8195	14
	(7420)	(9600)	(4164)	6	(7920)	(11109)	(8331)	7	(9360)	(10412)	(5696)	20
.07140	15120	20919	5552	10	54000	44760	19190	10	27360	32347	8612	13
.06120	36720	35144	11920	10	39600	44640	18120	10	38160	39092	14380	20
.04080	47520	41616	25200	10	47520	58608	25300	10	47520	50112	25330	20
.03060	...	...	...	...	42480	46160	14270	9	42480	46160	14270	20
.02040	46800	42476	33790	10	23750	27216	19930	9	34560	34546	25070	9
.01020	43200	47232	43620	10	36000	39600	34800	10	38160	43416	38710	20
.00510	51120	53568	38785	10	...	...	...	...	51120	53568	38785	20
Controls	44640	44208	28055	10	41040	45792	40400	10	43200	45000	33110	20

TABLE III  
OBSERVED AND CALCULATED SURVIVAL TIMES OF ROACHES INJECTED WITH POTASSIUM CYANIDE (EXPERIMENT 2),  
AND TIMES TO APPEARANCE OF RED COLOR IN THE BODIES OF THE INSECTS

CONCENTRATION (molar)	OBSERVED TIMES					CALCULATED <sup>1</sup> SURVIVAL TIME (minutes)	NUMBER OF INSECTS
	Survival Time (minutes)		Time to Appearance of Red Color (minutes)				
	Median	Arithmetic Mean	Harmonic Mean	Arithmetic Mean	Harmonic Mean		
0.4608	5	5	5	2959	2623	1338	5
.3072	6	1949	5	4597	3824	1956	7
	(5)	(5)	(5)	.....	.....	.....	4
.2304	2733	2911	12	3548	2864	2488	8
	(3444)	(3326)	(2483)	.....	.....	.....	7
.1935	2100	1844	46	5100	3730	2822	8
	(2786)	(2688)	(2557)	.....	.....	.....	5
.1536	1536	1999	6	3809	2756	3224	9
	(2330)	(2569)	(2042)	.....	.....	.....	7
.1229	2386	3049	2837	3818	2967	3495	10
	(30240)	(32054)	(10557)	32240	10888	3685	10
.09830	(5730)	(9012)	(5879)	(9300)	(6082)	.....	5
	3873	4879	3561	5065	3651	3445	12
.07680	3170	6976	3597	7084	3703	3029	9
.05760	(3012)	(4518)	(3246)	(4640)	(3343)	.....	8
	8865	22222	6880	22765	7995	4939	9
.03840	(5463)	(5530)	(4147)	(6129)	(4874)	.....	5
.01920	52560	46825	13835	47075	14310	13898	13
.007680	51840	50832	48170	.....	.....	.....	10
Controls	41040	44352	36560	44928	36835	.....	10

<sup>1</sup>Calculated by equation (14) [see 4] to fit the harmonic means in the preceding column after the subtraction of 360 minutes from each of those means.

TABLE IV  
RANGE OF MOLAR CONCENTRATIONS IN THE CRITICAL ZONE AND THE REGION OF INFLECTION FOR POISONS INDICATED

POISON	EXPERIMENT NO.	CRITICAL ZONE FOR—		REGION OF INFLECTION	
		Narcosis	Death	Including $c_0$	Minus $c_0$
NaCN.....	1 A	0.4080-0.1632	0.1020-0.0612	0.1224-0.1020	0.0724-0.0520
	1 B	.2040-.1428	.1326-.0612	.1326-.1122	.0826-.0622
	1 C	.4080-.1428	.1326-.0612	.1326-.1020	.0826-.0520
KCN.....	2	.3072-.1536	.0983-.0192	.0983-.0576	.0903-.0496
K <sub>4</sub> Fe(CN) <sub>6</sub> .....	3	.7292-.3646	.1823-.0608	.....	.....

of the bimodal frequency distribution at each concentration within the critical zones are shown in parentheses. These tables and Figure 2 show that, beginning at the highest concentration, as concentration decreases, a curve suddenly departs from near the concentration axis, going to, say, about 2000 minutes (NaCN curve), then passes through a region containing the critical zone for narcosis into a region of inflection, analogous to the region of inflection described previously for roaches injected with arsenicals. This region of inflection is overlapped by the upper part of the critical zone for death. The curve then passes through the lower part of the critical zone for death and reaches the survival-time neighborhood of the controls, where a survival-time value exceeding that of the controls may be attained. The limits of the two critical zones, and of the region of inflection before and after subtracting  $c_0^1$ , are given in Table IV for the three cyanide poisons.

At higher concentrations the errors involved in experiments 2 (KCN) and 3  $K_3Fe(CN)_6$  no doubt are greater than those in experiment 1 (NaCN), because the potassium salts seemed to facilitate hemorrhage. Nevertheless, the data indicate that, in general, the KCN curve is similar to the NaCN curve. Concentrations of  $K_3Fe(CN)_6$  higher than 0.7292 M were not used because of excessive hemorrhage. The data indicate that, for the concentrations used, the  $K_3Fe(CN)_6$  curve resembles the NaCN and KCN curves, except that a region of inflection is not apparent.

Figure 2 shows that the recovery curves rise fanwise from near the origin of the coordinate axes toward the concentration-survival time curve. The time between injection and recovery to a given symptomatic stage is represented by the vertical distance on the graph from the concentration axis to the recovery curve. Thus, at 0.2040 M NaCN, an average insect went from A to D (narcosis) in less than 5 minutes, remained D up to about 570 minutes, at which time it became  $M_2$ , remained  $M_2$  from about 570 to about 1700 minutes, when it died without further recovery. At 0.06120 M NaCN another average roach went to D (narcosis) in less than 5 minutes, was D from then to 22 minutes, was  $M_2$  from 22 to 107,  $M_1$  from 107 to 211, L from 211 to 373, S from 373 to 2885 minutes, after which it became A, indicating complete recovery from the narcotic effect of the poison. The recovery curves indicate that a maximum of recovery, not necessarily complete recovery, is reached. For some of the recovery curves in Figure 2 the symbol at certain concentrations has a + sign by it and the curve is drawn to the left of the symbol because some of the insects did not recover from the narcotic effect, and actually the average recovery time would be greater than the value indicated. It may be noted that at each lethal concentration the insects reached their maximum recovery roughly about halfway between the time of injection and the time of death. Although graphically it might seem that these recovery curves should continue until they reach or cross the concentration-survival time curve, only the  $M_2$  curve would reach approximately the death curve, for only the  $M_2$  symptomatic stage immediately precedes

<sup>1</sup> $c_0$  corresponds to a minimum lethal dose; see (4).



death. Insects in an  $M_1$  stage, for example, would again have to pass through an  $M_2$  condition before death. This is illustrated in Figure 1. The  $M_2$  curve (Fig. 2) reaches approximately the concentration-survival time curve somewhere between the points a and b, probably as shown in the figure. This approximate meeting of the two curves helps to explain the sudden departure of the concentration-survival time curve from the concentration axis toward the point b.

The concentration ranges in which different factors are considered to influence the form of the survival time curves for NaCN and KCN are indicated by the letters in the double column under "Concentration Range" in Table V. The approximate limits of each range are indicated by the short horizontal lines that separate the letters in the column. The concentrations that fall within each range may be read from the first column, headed concentration; for example, range B extends from just above 0.4080 M to just below 0.1428 M. Since some of the ranges overlap, the survival time associated with one concentration is affected by more than one factor and it is necessary to show them by a double column in the table. The characteristics of each concentration range, the limits of which are indicated in parentheses for experiment 1 C (NaCN), are as follows: (1) Range A (down through 0.6120), narcosis is the principal result measured; (2) Range B (0.4080–0.1428), critical zone for narcosis; (3) Range C (between 0.3060 and 0.2550), transition from narcosis to death, as the principal result measured; (4) Range D (0.2550–0.1326), range in and below which primarily death is measured; (5) Range E (0.1326–0.04080), critical zone for death; (6) Range F (0.1224–0.1020), region of inflection; (7) Range G (0.09180–0.04080), survival times progress regularly toward the survival time of the controls as concentration decreases; (8) Range H (0.3060–controls), survival times may be approximately equal to or greater than that of the controls; (9) Range I (below 0.00510), survival times are approximately the same as the survival time of the controls. A zero appears in the parts of the double column where no range is specified.

Considering the complexity of each of these concentration-survival time curves, one would hardly expect to obtain a single straight line by plotting the logarithm of concentration against the logarithm of observed survival time. When such a graph is made, the curve consists of several portions (probably as many as seven), in each of which a straight line could be drawn through the points. An expression such as  $(c-c_0)t_s = K$ , where  $c$  is injected concentration,  $c_0$  is minimum lethal concentration, and  $t_s$  is survival time, does not represent adequately one of these concentration-survival time curves as a whole, but values of  $(c-c_0)t_s$  are given in Table V. For example, in the range G, the average values of  $K$  and the values of  $c_0$  are  $K = 147$ ,  $c_0 = 0.008$  for KCN, and  $K = 177$ ,  $c_0 = 0.05$  for NaCN.

Because of the composite nature of these cyanide curves, particularly because the measures of central tendency are less exact in the critical zones, it has not been possible satisfactorily to calculate survival times from these data by means of the equations developed in the previous papers dealing with arsenicals. Nevertheless, approximate survival-time values, given in Table III, for roaches poisoned with KCN were calculated by means of equation (14) described previously (4).

TABLE V

OBSERVED SURVIVAL TIMES OF INJECTED ROACHES, VALUES OF K AND CONCENTRATION RANGES<sup>1</sup> FOR EXPERIMENTS 1 C (NaCN) and 2 (KCN)

CONCENTRATION (molar)	CONCENTRATION RANGE	SURVIVAL TIME (minutes)	K <sup>2</sup>
Experiment 1 C (NaCN)			
0.8160.....	A O	5	3.8
.6120.....	—	5	2.3
.4080.....	B	5	1.8
.3060.....	C	5	1.3
.2550.....	D	1579	324
.2040.....		723	111
.1632.....		1565	177
.1428.....		2540	236
.1326.....	E	7881	651
.1224.....	F	3709	269
.1122.....		3237	201
.1020.....		3124	162
.0918.....	G	4410	184
.0816.....		5699	180
.0714.....		8612	184
.0612.....		14380	161
.0408.....		25330	....
.0306.....	H O	14270	....
.0204.....		25070	....
.0102.....		38710	....
.0051.....		38785	....
Controls.....	I	33110	....
Experiment 2 (KCN)			
0.4608.....	A B	5	2.3
.3072.....	C	5	1.5
.2304.....	D	2483	552
.1935.....		2557	449
.1536.....		2042	297
.1229.....	O	2537	292
.0983.....	F E	5879	531
.0768.....		3561	245
.0576.....	G	3246	161
.0384.....		4147	126
.0192.....	H O	13835	155
.00768.....		48170	....
Controls.....		36560	....

<sup>1</sup>See text, p. 483.<sup>2</sup>K = (c-c<sub>0</sub>)t<sub>s</sub>.

Above the region of inflection these values might be considered to represent probable survival times of the inactivated roaches as indicated by the appearance of red color in their bodies. Below the inflection the calculated and the observed harmonic means agree about as well as could be expected, if the complexity of the curve and the errors involved are considered. The values of the constants used in making these calculations were  $K = 150$ ,  $c_0 = 0.008$ ,  $a = 5$ ,  $p = 0.25$ ,  $c_1 = 0.0576$ ,  $n = 2$ , and  $m = 2$ .

A comparison of the NaCN and KCN curves (Fig. 2, Tables II and III) shows that the inflection occurs at higher concentrations of NaCN than of KCN. If, however, the comparison is made on the basis of the approximate effective concentration ( $c - c_0$ ), instead of the injected concentration ( $c$ ), the regions of inflection agree more closely (Table IV).

The data for  $K_3Fe(CN)_6$  (Table VI) show that this poison is much less toxic when injected into the roach than is either NaCN or KCN. According to the generalized hypothesis proposed earlier in connection with sodium metarsenite the presence of an inflection in the NaCN and the KCN curves indicates that each of these poisons in solution within the organism exists as two different chemical species in equilibrium with each other, of which the one,  $x$ , is toxic and the other,  $y$ , is not toxic. The chemical identification of  $x$  and  $y$  is not made possible by the hypothesis but is a matter of physico-chemical interpretation. An interpretation, similar to that used in connection with sodium metarsenite, based upon an assumed incomplete ionization of the injected poison, would identify  $y$  as NaCN or KCN molecules and  $x$  as CN ions, corresponding respectively to sodium metarsenite molecules and arsenite ions postulated for the sodium metarsenite-injected roaches (4). But an alternative interpretation is considered more likely to be correct not only for the NaCN and KCN data presented here but also for the arsenical data reported earlier. According to this second interpretation the injected NaCN or KCN is completely ionized and the non-toxic cyanide ions,  $y$ , are in equilibrium with toxic hydrocyanic acid molecules,  $x$ , formed by hydrolysis of the cyanide ions; and the degree of hydrolysis varies inversely with total concentration of poison down to a critical concentration,  $c_0$ , below which complete hydrolysis is assumed. For the arsenite data, similarly interpreted,  $y$  would be arsenite ions, instead of sodium metarsenite molecules, and  $x$  would be arsenious acid molecules formed by hydrolysis of the arsenite ions, instead of arsenite ions. The toxic symptoms produced in roaches by  $K_3Fe(CN)_6$  were similar to those caused by KCN and NaCN, suggesting that all three poisons may affect the same tissue components, perhaps the same enzyme systems of the tissues. If it be supposed that these tissue components are affected by all three cyanides in the form of a single chemical species,  $x$ , CN ion according to the first interpretation or hydrocyanic acid molecules according to the second, it would appear that relatively not more than 3 per cent of the potentially available CN from the  $K_3Fe(CN)_6$  must have participated in the lethal action of the poison. With respect to any liberation of the CN component, this would seem to indicate that the ferricyanide radical has considerable stability, and may be

partly responsible for the failure of the  $K_3Fe(CN)_6$  data to indicate a region of inflection.

The fact that cyanide may produce a narcotic as well as a lethal effect upon an organism has been recognized for a considerable time in the literature dealing with the biological action of cyanides. In entomological literature this effect sometimes is designated by another term. For example, Bliss and Broadbent (1, 2), in reporting an extensive statistical analysis of the effects of hydrocyanic acid gas upon *Drosophila*, refer to a stupefaction effect. The authors have not found reports of extensive, cyanide concentration-survival time curves with

TABLE VI  
OBSERVED SURVIVAL TIMES OF ROACHES INJECTED WITH  $K_3Fe(CN)_6$

CONCENTRATION	SURVIVAL TIME			NUMBER OF INSECTS
	Median (minutes)	Arithmetic Mean (minutes)	Harmonic Mean (minutes)	
0 7292	256	241	235	4
6076	930	2264	278	10
	(780)	(1222)	(251)	9
4680	3600	4498	1287	10
4254	4320	5520	1323	10
	(5040)	(5501)	(3032)	9
3646	7420	6882	4707	10
3038	9360	8496	7940	10
2430	7920	8424	7071	10
	(7920)	(9040)	(8440)	9
1823	7920	11320	9757	10
1215	25200	26208	14140	10
06076	27800	33984	21715	10
006076	46080	47520	37640	10
.003038	36000	37872	33975	10
001519	53280	53856	35140	10
Controls	32200	37276	31740	10

which to compare those reported here. It is of considerable interest, however, that Graham<sup>2</sup>, in a study of the effects of a number of poisons on the respiration of tissues from the codling moth, obtained curves relating concentration of poison to inhibition of oxygen consumption, and that these curves show regions of inflection that may be analogous to those reported here for cyanide and previously for the arsenicals. The inflections found by Graham and by us for sodium cyanide and for sodium metarsenite occur at concentrations of poison that are not greatly different, when allowance is made for a dilution of the injected poison by the blood of the roach.

<sup>2</sup>Graham, Kenneth. Respiratory enzyme mechanisms and inhibitor action in tissues of codling moth larvae. [Unpublished thesis, University of Toronto, Canada], 1945.

## SUMMARY AND CONCLUSIONS

Concentration-survival time curves and concentration-recovery time curves for large nymphs of the American roach (*Periplaneta americana* (L.)) injected with NaCN, KCN, and  $K_3Fe(CN)_6$  were obtained. The potassium salts facilitated hemorrhage, thereby increasing experimental error. The symptomatic picture of these poisoned roaches was compared with that of roaches poisoned with sodium metarsenite used as a standard. The cyanide curves are complicated by the fact that the cyanides have both a narcotic and a lethal effect upon the injected insects. Whereas, once symptoms appear, arsenite-injected roaches progress continuously toward death, the cyanide-injected roaches may become completely inactivated (narcotized), partially or completely recover, and pass through successive symptomatic stages to death. The cyanides produce tremors temporarily, particularly during the early stages of poisoning. A cyanide concentration-survival time curve is complicated not only by the occurrence of both narcotic and lethal effects of the poisons but also by the existence of two critical zones, one for narcosis and one for death, and by the presence of a region of inflection analogous to the inflection in curves of arsenite-injected roaches reported previously. Thus, these cyanide curves are composite, representing time for complete narcosis in the upper concentrations and survival time in the lower lethal concentrations. In the intermediate concentrations they are transitional. These complexities render mathematical treatment of the data difficult. The  $K_3Fe(CN)_6$  appears to be less toxic than NaCN or KCN to the roach, possibly because of considerable stability of the ferricyanide radical.

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## LARVAE OF SOME GENERA OF ANTHRIBIDAE (Coleoptera)

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Most investigators who have been concerned with the relationships of the Anthribidae have believed that the family is at least related to the Rhynchophora. Several have included the family in that large group. Leconte (1876) stated that the Anthribidae should be placed in the Rhynchophora, since there were not sufficient reasons for excluding them. Böving and Craighead (1931), drawing their conclusions principally from studies of the larvae, have treated the Anthribidae as a superfamily, equal in rank to the Chrysomeloidea and the Curculionoidea. They have placed that superfamily, in a linear arrangement, between these latter two but have not indicated that they believed the Anthribidae more closely related to the Curculionidae than to the Chrysomelidae. Gardner, who has published one comprehensive paper (1936) and two smaller ones (1932, 1937) on the larvae of the Anthribidae of India, believes that the family belongs in the Rhynchophora. Emden (1938) also places it there. Crowson (1944), who has studied the metendosternite in Coleoptera, considers the Anthribidae to comprise one of six families of Rhynchophora.

The most recent paper to deal with the subject is that by Hoffman (1945). Unfortunately, however, Hoffmann's conclusions seem based upon faulty observation or misinterpretation. He places the Anthribidae and the Urodonidae (sic) (*Bruchela*) in the Chrysomeloidea. He states that the Chrysomeloidea are distinguished from the Curculionoidea by the presence in the larvae of the latter of a hypopharyngeal bracon which is absent in larvae of the Chrysomeloidea. Yet the anthribids and *Bruchela*, larvae of both of which clearly possess the bracon, are placed with the Chrysomelidae.

Conclusions drawn from study of the larvae,<sup>1</sup> partially reported in this paper, are that the Anthribidae represent a rather homogeneous section of the Rhynchophora. They possess the characteristics of larvae of the Rhynchophora considered essential to separate them from other families of the Polyphaga. These characteristics are: Gular region or median gular suture absent; hypopharyngeal bracon present (except *Rhynchaenus* and *Rhamphus*, fide Emden (1938), *Attelabus*, *Apoderus* and probably others); urogomphi (in the strict sense) absent; tenth abdominal segment in front of anus without a pair of soft, oval lobes separated by a longitudinal groove; mala not borne on palpiger; legs

<sup>1</sup>I have not studied larvae of the Scolytidae, Platypodidae and smaller, related families. Generalizations on rhynchophorous larvae may or may not apply to those families.

usually absent, when present without claw; clypeus almost always well defined; spiracles not cribriform.

With a few exceptions, such as *Bruchela* by which they may be related to the Bruchidae<sup>2</sup> and *Cimberis* through which they appear to be related to the remainder of the Rhynchophora, the Anthribidae can be characterized readily. The purpose of this paper is to define the family, indicating how it may be separated from other Rhynchophora, and present keys to the mature larvae of the subfamilies and genera. Only the larvae which have been available for study have been included, although reference is made to some of those described by Gardner.

Keys to the species have not been prepared. Emden (1938) has shown that larvae of at least some genera of Rhynchophora are separable to species. However, specific identification is hazardous since the larvae of only 25 per cent of the species of Anthribidae known to occur in America, north of Mexico, have been studied. These larvae are distributed in approximately 50 per cent of the North American genera. It follows that identification to genus can be made with much more assurance than can identification to species. Some of the genera are represented in our fauna by only one species; in those genera specific identification is possible.

Unless indicated otherwise, identifications of all larvae included in this paper were made from reared adults. Some larvae which represent undetermined North American species and which represent undetermined genera have been included in the keys. It is expected that at some future date the identity of these larvae will be established and their position in the classification will thus be indicated. Undetermined larvae from localities outside the United States have not been included. As an example, an interesting, robust larva from seeds of *Styrax* spp., from Japan and China, has been omitted from the keys.

No satisfactory way has been devised for measuring and expressing the size of the larvae. The over-all length of mature specimens of a given species will vary considerably depending upon the method of killing before preservation. General statements have been made, however, in an attempt to indicate the comparative sizes of the larvae; as small, moderately large, and large. The length of the larvae studied ranges from about 2.5 mm. (*Choragus*) to about 15 mm. (*Platyrhinus*). As an added guide to size, the greatest width of the head for any representative of the given genus has been indicated.

<sup>2</sup>In a former paper (1943) I have discussed the essential differences between the Anthribidae, including *Bruchela*, and the Bruchidae. Since that paper was published it has been discovered that the tracheal system of bruchid larvae provides an additional means of separating the families. In the tracheal system of all bruchid larvae available for study (approximately 37 species representing 17 genera, see Bridwell (1946)), with the exception of *Acanthoscelides alboscuteellatus* (Horn) and *A. calvus* (Horn), there is a series of air sacs. In the majority of species these consist of four separate, distinctly enlarged chambers in the main tracheal branches on each side of the body, three closely associated with the first abdominal spiracle, the fourth with the second abdominal spiracle. In other species, at least generically distinct from those with 4 pairs, there may be 9 or 10 pairs, distributed along the tracheal system in the abdominal segments. No enlargements of the branches of the tracheae have been observed in the larvae of Anthribidae, including *Bruchela*, nor in any other rhynchophorous larva. The function of these sacs is not apparent.

The following couplet is offered as a means of separating the larvae of Anthribidae from those of other Rhynchophora.

- Ultimate and penultimate articles of maxillary palpus each with a short seta (figs. 38, 42); labral rods<sup>a</sup> absent; labral tormae present (figs. 45, 47, 51) or rarely absent; legs usually discernible. . . . . **Anthribidae**
- Without the combination of characters given above. Ultimate article of maxillary palpus without seta (except *Belus* in which antenna consists of two subcylindrical, sclerotized articles, and Attelabinae (including *Rhynchites* and its allies) in which labral rods are present and long); labral rods present (except *Belus* and *Proterhinus*) occasionally modified; labral tormae absent (except *Belus* in which palpiger is present and bears distinctly more than three setae, and *Proterhinus* in which the ultimate article of maxillary palpus is without seta); legs not discernible (except some Brentidae such as *Arrhenodes* and *Brenius*). . . . . **Rhynchophora** (major part)

#### FAMILY CHARACTERIZATION

Body setae sparse to abundant, at least moderately abundant ventrally on prothorax (except *Bruchela rufipes* (Oliv.)). Hypopharyngeal sclerite usually present and well developed. Antenna consisting of one membranous article which bears a conical to subconical sensory appendage. Anterior margin of frons, between the catapophyses, considerably wider than basal margin of clypeus (except *Bruchela rufipes*). Labrum with one pair of basal sensilla, without anterior or median sensilla. Labral rods absent, labral tormae present or, rarely, absent (*Bruchela rufipes* and *Cimberis pilosus* (Lec.)). Posterior margin of prementum straight or nearly straight, not distinctly angulate (labium not subdivided in *Holostilpna*). Mentum and submentum distinguishable (except *Holostilpna* and *Bruchela*). Ultimate and penultimate articles of maxillary palpus each with a short seta. Palpiger absent (except *Cimberis*). Mala nearly always with thornlike lacinia near middle of inner margin. Legs usually discernible, often with two articles but without pointed tarsungulus.

Larva small to moderately large, usually subcircular in cross section. Frontal suture complete anteriorly, or at least not terminating at antenna. Hypopharyngeal bracon present. Head nearly always with moderately numerous to abundant setae. Anterior ocellus present or absent, posterior ocellus absent. Antenna nearly always with a few minute processes (? setae) in addition to sensory appendage. Labrum with four or more than four pairs of setae. Epipharynx with a pair of anteromedian sensilla (except *Bruchela* and *Cimberis*) and two pairs of peg-shaped sensilla (except *Cimberis* with one pair and *Bruchela* with none). Mandible usually with mola, the outer surface of the mandible with two setae (except *Euparius* and *Eurymycter*). Labium usually small. Labial palpi absent, or present and each with one or two articles. Premental sclerite usually present. Prementum with one pair to several pairs of setae. Submentum broad with usually more than three pairs of setae. Maxillary palpus with two or three articles. Stipes with several to numerous setae (except *Cimberis* with two). Mala with setae, the dorsal setae when present not arranged in an evident row.

<sup>a</sup>For an explanation of this and other terms see Anderson (1947).



Thoracic spiracle either in mesothorax or situated between prothorax and mesothorax. Spiracle bicameral (figs. 8, 11, 12), unicameral (figs. 10, 13) or without air tubes (fig. 9).

Abdomen with eight pairs of spiracles. Spiracles bicameral, unicameral or without air tubes; the orifice oval to subcircular. Typical abdominal segments with two dorsal folds. Sternellum absent.

#### KEY TO SUBFAMILIES OF ANTHRIBIDAE

1. Head deeply retracted into pronotum, distinctly longer than broad (fig. 19); labial palpi absent; mentum and submentum not distinguishable, *Bruchelinae* (p. 492)  
 Head free or only slightly retracted into pronotum, nearly as broad as or broader than long (figs. 16, 17, 18); labial palpi present; mentum and submentum distinguishable. . . . . 2
2. Mandible without ventral process (fig. 23); mala broadly rounded or acute, the apical margin not straight (figs. 39-42); clypeus distinguishable from frons (figs. 16, 18); epipharynx with two pairs of peg-shaped sensilla (figs. 45, 47-51); (labium often considerably reduced in size), *Anthribinae* (p. 497)  
 Mandible with low ventral process (fig. 22); apical margin of mala straight or slightly emarginate (fig. 38); clypeus and frons fused (fig. 17); epipharynx with one pair of peg-shaped sensilla (fig. 52); (labium not reduced in size). . . . . *Cimberinae* (p. 515)

#### Subfamily Bruchelinae

Larva small, slender, gradually tapering posteriorly. Head deeply retracted into pronotum, distinctly longer than broad. Labium without palpi. Mentum and submentum not distinguishable. Abdominal spiracles unicameral.

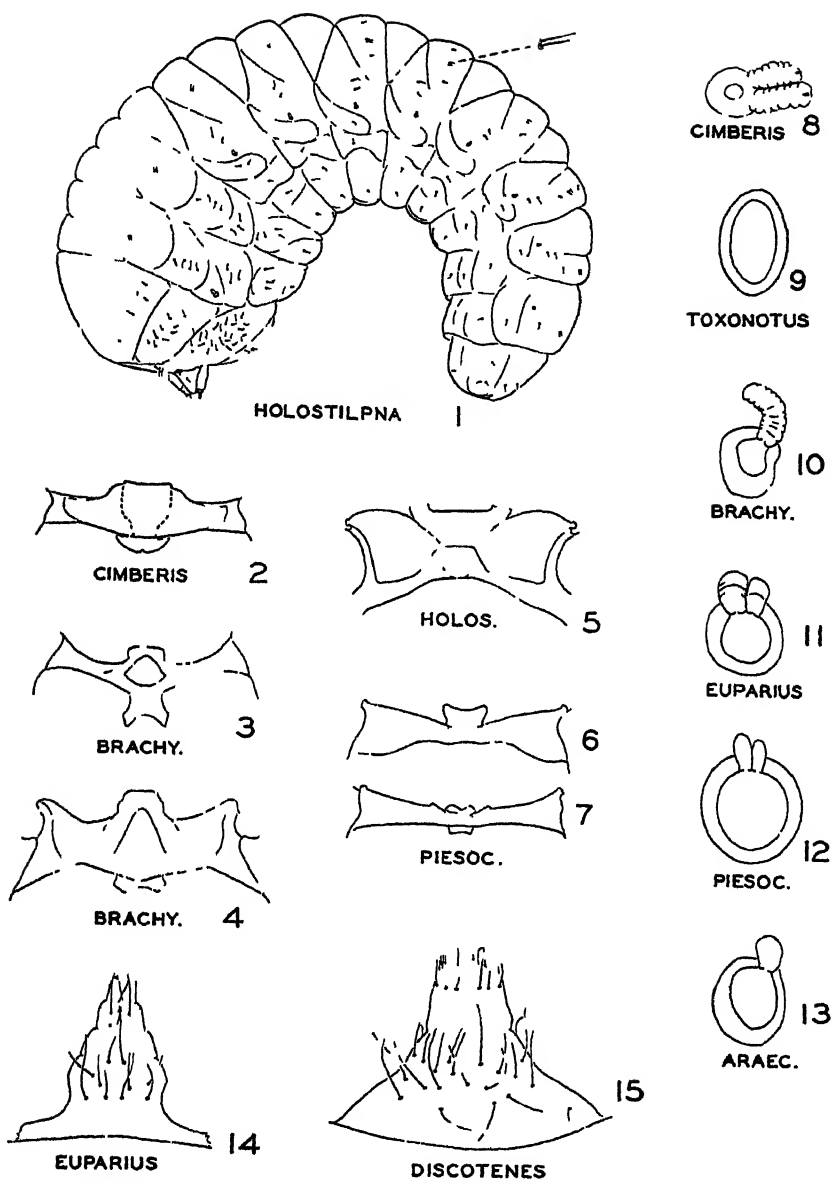
Body without pigmented sclerites. Posterior tentorial arms united or not united in the middle line. Head with few setae, these confined to anterior one-third of head capsule. Labrum with four pairs of setae. Two pairs of median spines of epipharynx present, each pair transversely arranged. Maxillary palpus with two articles. Anus terminal, i. e., in center of posterior end of body.

It is quite apparent that the larva of *Holostilpna* is not closely related to that of *Bruchela*. On the other hand it seems evident that both genera belong in the Anthribidae. If that is true, the absence of labial palpi, a striking characteristic common to both genera, makes it convenient to treat them together.

#### EXPLANATION OF PLATE I

Fig. 1. Lateral view of *Holostilpna nitens*,  $\times 35$ . Fig. 2. Hypopharyngeal bracon of *Cimberis pilosus*,  $\times 75$ . Fig. 3. Same of *Brachylarsooides alternatus*,  $\times 50$ . Fig. 4. Same of *Brachylarsooides sticticus*,  $\times 100$ . Fig. 5. Same of *Holostilpna nitens*,  $\times 100$ . Fig. 6. Same of *Piesocorynus* sp., probably *dispar*, feeding larva,  $\times 30$ . Fig. 7. Same of *Piesocorynus* sp., probably *dispar*, prepupal larva,  $\times 30$ . Fig. 8. Abdominal spiracle of *Cimberis pilosus*,  $\times 325$ . Fig. 9. Same of *Toxonotus fascicularis*,  $\times 200$ . Fig. 10. Same of *Brachylarsooides alternatus*,  $\times 200$ . Fig. 11. Same of *Euparius marmoreus*,  $\times 200$ . Fig. 12. Same of *Piesocorynus* sp., probably *dispar*,  $\times 200$ . Fig. 13. Same of *Araecerus fasciculatus*,  $\times 200$ . Fig. 14. Labium of *Euparius marmoreus*,  $\times 50$ . Fig. 15. Same of *Discoitenes nigrotuberculata*,  $\times 100$ .

(All figures drawn by author)



## KEY TO GENERA OF BRUCHELINAE

- Lateral margins of occipital foramen not interrupted; head brown; prodorsum bearing ampullalike protuberances on at least metathorax and abdominal segments I to VII; hypopharyngeal sclerite absent or indistinct, I. *Bruchela* (p. 494)
- Lateral margins of occipital foramen interrupted by incomplete ball-and-socket joint; head lightly pigmented; prodorsum of thoracic and abdominal segments not bearing ampullalike protuberances; hypopharyngeal sclerite present, distinct. . . . . II. *Holostilpna* (p. 496)

I. Genus *Bruchela* Dejean

(Figs. 19, 28)

*Bruchela* Dejean, Catalogue de la collection de Coléoptères, p. 78, 1821.*Urodon* Schoenherr, Isis von Oken, heft 10, p. 1134, 1823. (The synonymy is that of Bridwell (1932) and is based upon the acceptance of the catalog names of Dejean.)

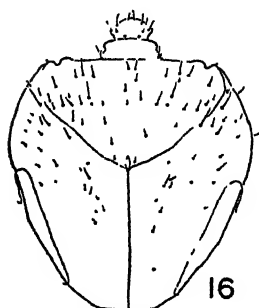
Larva oval to subcircular in cross section, scarcely thicker through thorax. Prodorsum with protuberances, at least on metathorax and abdominal segments I to VII. Head brown, with non-pigmented, longitudinal dorsal stripes. Mandible without mola. Legs or evidence of legs completely absent.<sup>4</sup>

Body setae sparse to numerous. Head widest near the middle, oval posteriorly. Frontal suture discernible throughout its length. Endocarina present, approximately one-half as long as frons. Lateral margins of foramen magnum not interrupted. Hypopharyngeal sclerite only indicated. Posterior tentorial arms united or not united in the middle line. Anterior one-third of head with few setae. Ocellus distinct. Antenna apparently without minute processes (? setae), the accessory appendage slender. Clypeus at most only vaguely distinguishable from frons. Anterior margin of labrum nearly straight or slightly emarginate. Labral tormae present and slender, or apparently absent. Epipharynx with one or two anterolateral and four anteromedian setae. Epipharynx apparently without sensilla; without asperities. Mandible with two subequal apical teeth and a shorter, subterminal dorsal tooth. Stipes with four (*B. rufipes*) to eight (*B. lilii*) setae. Mala with (*lilii*) or without (*rufipes*) thornlike lacinia near

<sup>4</sup>Each generic description is usually made up of two parts, a short review of the more important diagnostic characters followed by a more detailed description. Each description is followed by a statement of the material upon which it is based. All larvae are in the collection of the United States National Museum.

## EXPLANATION OF PLATE II

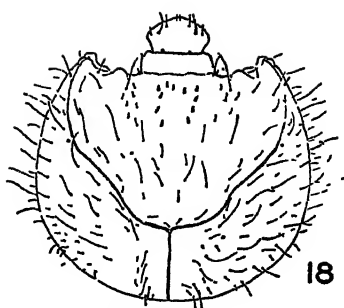
Fig. 16. Dorsal view of head of *Piesocorynus* sp., probably *dispar*, feeding larva,  $\times 20$ . Fig. 17. Dorsal view of head of *Cimberis pilosus*,  $\times 55$ . Fig. 18. Same of *Euparius marmoreus*,  $\times 25$ . Fig. 19. Same of *Bruchela lilii*,  $\times 50$ . Fig. 20. Dorsal view of left mandible of *Discotenes nigrotuberculata*,  $\times 100$ . Fig. 21. Same of right mandible of *Anthrribus albinus*,  $\times 30$ . Fig. 22. Ventral view of left mandible of *Cimberis pilosus*,  $\times 100$ . Fig. 23. Same of right mandible of *Araecerus fasciculatus*,  $\times 55$ . Fig. 24. Dorsal view of right mandible of *Phenocobiella chamaeropsis*,  $\times 30$ . Fig. 25. Same of left mandible of *Euparius marmoreus*,  $\times 55$ . Fig. 26. Lateral view of head of *Araecerus fasciculatus*,  $\times 25$ . Fig. 27. Same of *Ormscus* sp. (Nicholson, Miss., dead persimmon limb),  $\times 25$ .



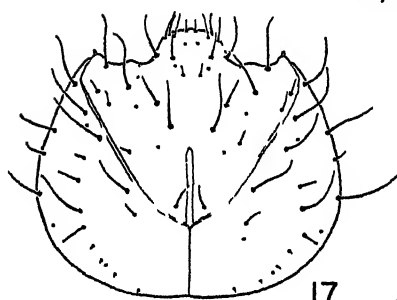
PIESOC.



DISCOT. 20



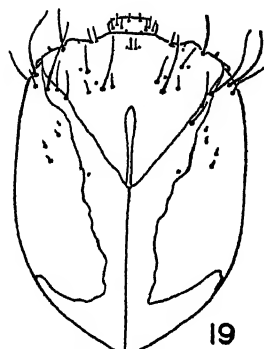
EUPARIUS



CIMBERIS



ANTHR. 21



BRUCHELA



CIMB. 22



ARAECERUS 26



PHOEN. 24



ARAEC. 23



ORMISCUS 27



EUPAR. 25

middle of inner margin. Mala with several setae on ventral surface, near apex, and with (*lilii*) or without (*rufipes*) dorsal setae.

Pronotum with setae numerous (*lilii*) or sparse (*rufipes*). Thoracic spiracle unicameral or bicameral,<sup>5</sup> the air tubes not annulated. Areas of thorax with comparatively few (*rufipes*) or with numerous (*lilii*) setae.

Air tube of abdominal spiracles not annulated, the peritreme sub-circular. Prodorsum of typical abdominal segments with prominent, bifid, ampullalike protuberance. Abdominal areas with setae numerous or sparse, no two of the postdorsal setae contiguous at base. Asperities inconspicuous or apparently absent.

Width of head: up to 0.67 mm.

*B. rufipes* (Oliv.). Schonebeck a. d. Elbe, Germany, July 19, 1912, C. Urban. Presented by Emden. As reported by Urban (1913), larvae of *rufipes* feed in seed capsules of *Reseda lutea* L. In the autumn they go into the ground, forming an oval cocoon. Pupation takes place the following spring. After a short pupal period the beetles emerge and eggs are laid in young seed capsules of the host plant.

*B. lilii* (Fähr.). Cape Town, South Africa, June 2, 1917, in seeds of *Gladiolus*. From the South African Museum.

Larvae of this genus have been characterized by Emden (1938) and described more completely by Urban (1913) under the generic name *Urodon*. The two species can be separated readily. In *lilii* a small sclerite is present at the base of the indistinctly developed prementum, the lacinia is represented by a small spine, and the posterior tentorial arms are united in the middle line. The larva of *rufipes* does not have a sclerite at base of prementum, the lacinia is absent and the posterior tentorial arms are not united in the middle line.

## II. Genus *Holostilpna* Jordan

(Figs. 1, 5)

*Holostilpna* Jordan, *Biologia Centrali-Americana*, v. 4, pt. 6, p. 382, 1907.

Larva slightly thicker anteriorly than in the middle. Lateral margins of foramen magnum interrupted three-fifths the distance from mandibular fossa to posterior margin of head, the interruption resembling an imperfect ball-and-socket joint. Posterior tentorial arms not united in the middle line. Labium undivided, triangular. Mala without lacinia.

Prodorsum on abdominal segments without protuberances. Body setae inconspicuous, very sparse except on pedal and sternal areas of prothorax. Head not pigmented except on extreme anterior border, widest slightly behind the middle, abruptly tapering posteriorly. Frontal suture absent posteriorly, discernible anteriorly. Endocarina absent. Hypopharyngeal sclerite well developed. Internal epicranial ridge present. Ocellus absent. Antenna with one minute process (? seta) in addition to sensory appendage. Labrum slightly rounded anteriorly. Labral tormae present, short, moderately stout. Epipharynx with three anterolateral and four anteromedian setae. Two pairs of peg-shaped sensilla present on epipharynx, one pair in front of,

<sup>5</sup>In a previous paper (1943) I stated that all spiracles of the larvae of *Bruchela* are unicameral. That statement is in error.

the other behind, anterior pair of median spines. Epipharynx with a few slender, inconspicuous asperities posteriorly. Mandible with two apical teeth; the mola flattened or slightly concave, smooth. Labium with two elongate setae near base and two beyond the middle. Premental sclerite absent. Stipes with four or five setae ventrally and one seta dorsally. Mala with numerous ventral setae and a few dorsal setae.

Pronotum with few dorsal setae, the setae more abundant laterally. Thoracic spiracle unicameral, the air tube with poorly developed annulations. Legs absent, their position indicated by a few setae. Pedal area of prothorax with numerous setae, of mesothorax and metathorax with few setae. Sternum of prothorax with numerous setae, of mesothorax and metathorax with one or two setae on each side. Remainder of areas of thorax with setae very sparse or absent.

Air tube of abdominal spiracles weakly or not annulated. Abdominal areas with the setae sparse, two of the setae on postdorsum with their bases adjacent. Asperities very fine, generally distributed.

Width of head: up to 0.47 mm.

*H. nitens* (Lec.). University Park, Md., winter 1942-43, in *Hypoxylon atropunctatum* (Schw.) Cke., a fungus growing in the bark of dead black oaks, W. H. Anderson. The larvae remain in the fungus throughout the winter; pupation takes place in the fungus in the spring or early summer. The essential characteristics of the larva have been pointed out previously (Anderson, 1943).

In view of the differences in structure between the larva of *Holostilpna* and that of *Choragus* (see p. 514), there can be little doubt that *Holostilpna* should stand as a distinct genus, and not as a subgenus of *Choragus*.

### Subfamily Anthribinae

Head free or nearly free, often with flattened area on each postero-lateral surface, nearly as broad as or broader than long, the lateral margins often nearly straight and convergent behind the middle. Hypopharyngeal sclerite well developed (except *Discotenes*, Genus X, and prepupal larvae of *Piesocorynus*). Ocellus often distinct. Clypeus readily distinguishable from frons. Anterior margin of labrum rounded (except *Phloeobius*, with a shallow emargination). Labrum with four or more than four, pairs of setae. Labral tormae present. Two pairs of peg-shaped sensilla present on epipharynx. Mandible without ventral process. Labium often reduced in size. Labial palpus with one or two articles. Maxillary palpus with two or three articles. Mala with lacinia near middle of inner margin (except *Phloeobius*).

Legs discernible (except *Araecerus*), ranging in development from a very low, rounded projection to legs with two distinct articles.

### KEY TO GENERA OF ANTHRIBINAE

1. Abdominal spiracles bicameral (figs. 11, 12) or without air tubes (fig. 9); labial palpus with two articles (except *Euparius* (fig. 14), the only known genus in which a small sclerite is present anteriorly on epipharynx (fig. 45)); (maxillary palpus often with three articles) . . . . . 4
- Abdominal spiracles unicameral (figs. 10, 13); labial palpus with one article; (maxillary palpus with two articles) . . . . . 2

2. Thoracic spiracle bicameral; head capsule rounded posterolaterally (as in fig. 18)..... 3
- Thoracic spiracle unicameral; head capsule obviously flattened posterolaterally (as in fig. 16).....XX. *Choragus* (p. 514)
3. Abdominal spiracles with air tube elongate and clearly annulated (fig. 10); legs short but distinct (fig. 31); prodorsum on typical abdominal segments not plicate.....XVIII. *Brachytarsoidea* (p. 512)
- Abdominal spiracles with air tube short, oval, without annulations (fig. 13); legs absent, each replaced by a cluster of setae (fig. 35); prodorsum on typical abdominal segments plicate.....XIX. *Araecerus* (p. 513)
4. Labrum with 10 or more than 10 pairs of setae (fig. 46); spiracles of known North American species without air tubes; epipharynx with distinctly more than 7 pairs of setae, including median spines (figs. 48, 50); pronotum with lateral, rodlike thickening; (maxillary palpus with three articles)..... 5
- Labrum with four pairs of setae (as in fig. 44) (except Genus X); spiracles bicameral; epipharynx usually with seven pairs of setae, including median spines (figs. 45, 47, 49, 51); pronotum usually without rodlike thickening; (maxillary palpus with two or three articles)..... 9
5. Lacinia absent; anterior margin of labrum emarginate; four median spines present on epipharynx; asperities on abdomen abundant, developed as velvety pubescence.....III. *Phloeobius* (p. 499)
- Lacinia present (figs. 39-41); anterior margin of labrum rounded (fig. 46); more than four median spines present on epipharynx (figs. 48, 50); asperities on abdomen sparser, not developed as velvety pubescence..... 6
6. Median spines of epipharynx moderately numerous to abundant, directed transversely or anteriorly (fig. 48); dorsal surface of mala without tuft of setae..... 7
- Median spines of epipharynx abundant, short, the majority of them directed posteriorly (fig. 50); dorsal surface of mala, immediately above base of lacinia, with a brushlike tuft of setae.....VII. *Toxonotus* (p. 504)
7. Anterior two-thirds of frons reddish orange.....IV. *Phoenicobiella* (p. 500)
- Pigmentation of frons, if present, confined to a transverse, marginal darkening..... 8
8. Mala broadly rounded apically (fig. 40); lacinia short, scarcely longer than basal width (European species).....V. *Anthrribus* (p. 502)
- Mala narrower apically (as in fig. 41); lacinia twice as long as basal width (American species).....VI. *Neanthrribus* (p. 504)
9. Abdominal segment IX with three fleshy protuberances on dorsal surface near posterior margin, one median, and one each side; proventriculus with bands of prominent asperities.....10
- Abdominal segment IX without fleshy protuberances; proventriculus without asperities.....11
10. Maxillary palpus with three articles; legs elongate, with two distinct articles.....VIII. *Meconemus* (p. 505)
- Maxillary palpus with two articles; legs very short, each with one article (fig. 29).....IX. *Discotenes* (p. 506)
11. Labrum with nine or ten pairs of setae; eight to ten median spines of epipharynx present.....X. Genus unknown (p. 506)
- Labrum with four pairs of setae; four median spines of epipharynx present.....12
12. Head capsule slightly retracted into pronotum, with flattened area on each posterolateral surface, usually broadest before the middle (fig. 16), scarcely pigmented anteriorly, not pigmented posteriorly.....13
- Head capsule completely free, without such a flattened area, subcircular, broadest at the middle (fig. 18), distinctly and uniformly pigmented throughout.....16
13. Maxillary palpus with three articles; (legs distinct, with two articles (fig. 36)).....14
- Maxillary palpus with two articles; (legs usually short and indistinct).....15
14. Prementum with one or two pairs of setae; posterior pair of median spines of epipharynx transversely arranged; pronotum with lateral, rodlike thickening.....XI. Genus unknown (p. 507)
- Prementum with four or five pairs of setae; posterior pair of median spines of epipharynx longitudinally arranged; pronotum without lateral rodlike thickening.....XII. *Piesocorynus* (p. 507)

15. Legs elongate, with two articles; apical article of labial palpus as broad at base as long; anterior pair of median spines of epipharynx situated between the anterior and posterior pairs of peg-shaped sensilla, the posterior pair of median spines longitudinally arranged (fig. 49),  
XIII. Genus unknown (p. 508)  
Legs very short, scarcely discernible; apical article of labial palpus nearly twice as long as broad; anterior and posterior pairs of peg-shaped sensilla close together, situated approximately between the spines of anterior pair of median spines of epipharynx, the posterior pair of spines transversely arranged (fig. 47).....XIV. *Ormiscus* (p. 509)
16. Maxillary palpus with three articles; labial palpus with two articles.....17  
Maxillary palpus with two articles; labial palpus with one article (fig. 14),  
XVII. *Euparius* (p. 511)
17. Epipharynx with three anterolateral setae; posterior pair of median spines of epipharynx longitudinally arranged; head brown,  
XV. *Platyrhinus* (p. 510)  
Epipharynx with approximately ten anterolateral setae; posterior pair of median spines of epipharynx transversely arranged; head light orange,  
XVI. *Eurymycter* (p. 511)

### III. Genus *Phloeobius* Schoenherr

*Phloeobius* Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Anterior margin of pronotum deeply emarginate, each half of the widely interrupted paired sclerite with its anterior border slightly projecting, brown. Labrum with approximately 10 pairs of setae. Epipharynx with numerous setae anterolaterally, at least two antero-medial setae and four median spines. Lacinia absent. Mala broadly rounded apically. Pronotum with lateral rodlike thickening. All spiracles oval, without air tubes. Asperities developed as patches of velvety pubescence.

Larva moderately large and robust, bluntly wedge-shaped posteriorly, the dorsal surface of abdominal segment IX with two subparallel longitudinal grooves. Body setae numerous, short, slender, inconspicuous. Head pale orange, with flattened area on each posterolateral surface, as broad as long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture discernible throughout its length. Endocarina present, not deeply pigmented, approximately one-half as long as frons. Anterior one-third of head thickly set with short setae, the setae sparser posteriorly. Ocellus apparently absent. Antenna in a large oval depression. Anterior border of labrum shallowly emarginate. Labral tormae elongate, convergent posteriorly. Numerous short asperities present near the middle of epipharynx. Mandible oblique apically, with large, smooth mola. Labial palpus with two articles, the palpi nearly contiguous at base. Ligula elongate, conical, projecting beyond apex of labial palpi, densely set with short asperities. Prementum with two pairs of very short setae. Premental sclerite not discernible. Submentum with more than ten short to elongate setae. Maxillary palpus with three articles. Stipes with abundant setae dorsally and ventrally. Mala with numerous setae dorsally and ventrally.

Setae on pronotum moderately sparse, short. Legs very short, the two articles vaguely separated, each article bearing several short setae. Abdominal areas with numerous setae. Anus subterminal. Width of head: up to 2.3 mm.



*P. pilipes* Jord. Hoftong, Cachar, Assam, May 13, 1929, ex *Lagerstroemia flos-reginae*, C. F. C. Beeson. Presented by J. C. M. Gardner.

Gardner (1932) describes the larva of *P. pilipes* and also that of *P. gigas* (F.). He states that the larva of *gigas* differs from that of *pilipes* in having the thoracic spiracle bicameral and the abdominal spiracles unicameral, the air tubes minute. In a later paper (1936) he states, indirectly, that the abdominal spiracles are bicameral in the larva of *P. gigas*.

#### IV. Genus *Phoenicobiella* Cockerell

(Figs. 24, 34, 39)

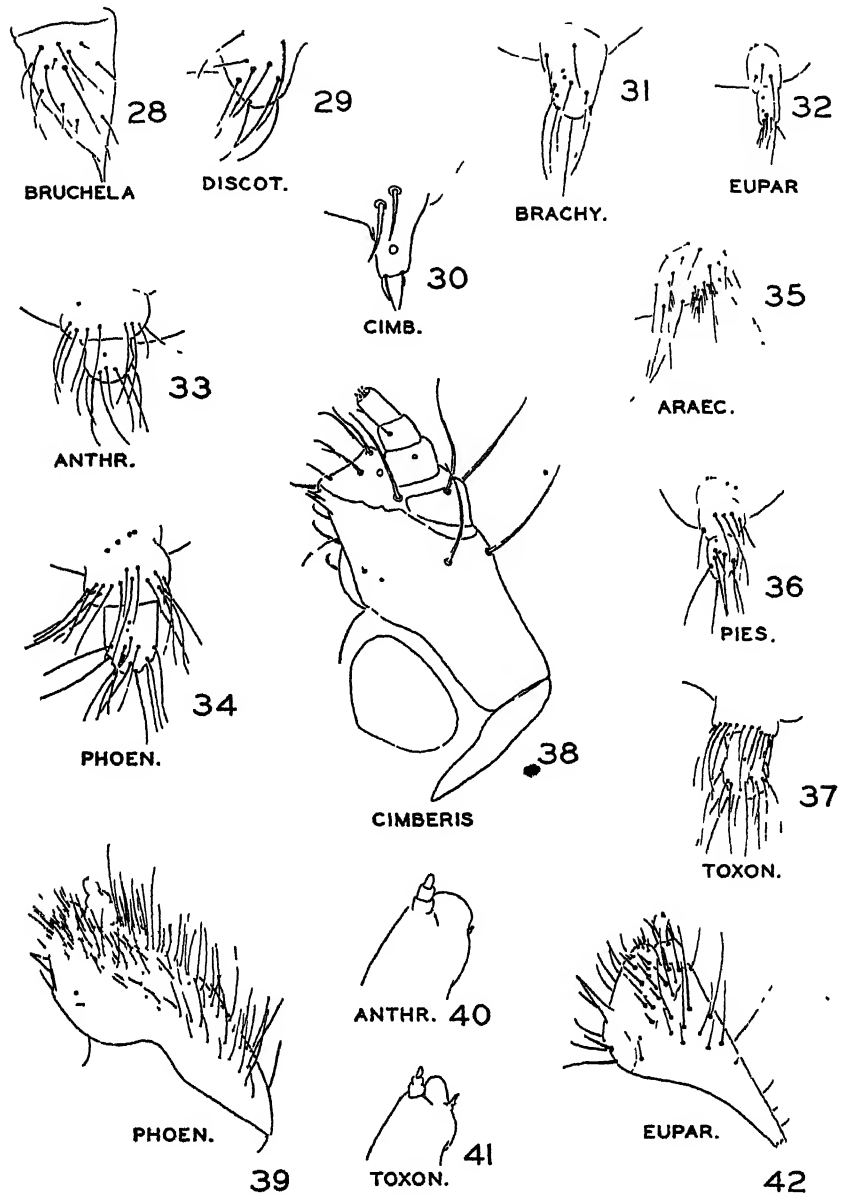
*Phoenicobiella* Cockerell, Ent. News 17: 243, 1906.

Anterior two-thirds of frons reddish orange, the remainder of head not pigmented. Labrum with 12 to 14 pairs of setae. Twenty to 24 pairs of median spines of epipharynx present, transversely or anteriorly directed. Mandible without projection near middle of dorsal inner margin. Labial palpus with two articles. Maxillary palpus with three articles. Mala rounded apically, dorsal surface without tuft of setae. Lacinia moderately long. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval, without air tubes.

Larva moderately large and robust, thicker anteriorly, bluntly wedge-shaped posteriorly, the dorsal surface of abdominal segment IX with two parallel longitudinal grooves. Pronotum without pigmented sclerite. Body setae numerous, inconspicuous, more abundant ventrally on thoracic segments. Head with flattened area on each postero-lateral surface, slightly broader than long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture distinct throughout its length, nearly straight posteriorly. Endocarina present, nearly one-half as long as frons. Head with numerous short, slender setae. Ocellus not discernible. Antenna very small, not overhung by extension from frons. Labral tormae strong, elongate. Apex of mandible usually obliquely gouge-shaped, mola slightly flattened, nearly smooth. Ligula present. Prementum without sclerite, with two or three pairs of setae. Submentum with several pairs of elongate setae. Stipes and mala with many setae dorsally and ventrally.

#### EXPLANATION OF PLATE III

Fig. 28. Metathoracic pedal area of *Bruchela lillii*,  $\times 50$ . Fig. 29. Prothoracic leg of *Discotenes nigrotuberculata*,  $\times 200$ . Fig. 30. Metathoracic leg of *Cimberis pilosus*,  $\times 325$ . Fig. 31. Mesothoracic leg of *Brachytarsoides alternatus*,  $\times 100$ . Fig. 32. Prothoracic leg of *Euparius marmoreus*,  $\times 50$ . Fig. 33. Same of *Anthrribus albinus*,  $\times 75$ . Fig. 34. Same of *Phoenicobiella chamaeropis*,  $\times 75$ . Fig. 35. Metathoracic pedal area of *Araecerus fasciculatus*,  $\times 50$ . Fig. 36. Metathoracic leg of *Piesocorynus* sp., probably *dispar*,  $\times 50$ . Fig. 37. Prothoracic leg of *Toxonotus fascicularis*,  $\times 75$ . Fig. 38. Ventral view of left maxilla of *Cimberis pilosus*,  $\times 160$ . Fig. 39. Same of *Phoenicobiella chamaeropis*,  $\times 50$ . Fig. 40. Ventral view of right maxilla of *Anthrribus albinus*, setae omitted,  $\times 30$ . Fig. 41. Same of *Toxonotus fascicularis*,  $\times 30$ . Fig. 42. Ventral view of left maxilla of *Euparius marmoreus*,  $\times 55$ .



Pronotum very deeply emarginate, nearly divided in the middle, with setae short and sparse. Legs short, clearly biarticulate, with numerous elongate setae, the apical article cylindrical, longer than wide at base.

Setae sparse on dorsal and ventral surfaces of abdomen, more abundant laterally. Asperities not discernible. Anus ventro-terminal.

Width of head: up to 2.3 mm.

*P. chamaeropsis* (Lec.). Savannah, Ga., March 31, 1884, G. Noble. Miami, Fla., April 17, 1918, and March 1, 1919, dead leaf stems of cabbage palmetto, T. E. Snyder.

## V. Genus *Anthribus* Geoffroy

(Figs. 21, 33, 40, 48)

*Anthribus* Geoffroy, Histoire abregee des insectes qui se trouvent aux environs de Paris, p. 306, 1762.

Labrum with 11 or 12 pairs of setae. Epipharynx with approximately 25 setae on each side, the median spines transversely or anteriorly directed. Mandible with prominent projection near middle of dorsal inner margin. Maxillary palpus with three articles. Mala very broadly rounded apically, dorsal surface without tuft of setae. Lacinia very short, scarcely longer than wide at base. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval.

Larva moderately large and robust, stouter through thorax, the dorsal surface of abdominal segment IX scarcely flattened, with two indistinct longitudinal grooves. Epipleurum moderately prominent on abdominal segments II, III and IV. Pronotum with lightly pigmented, paired sclerite. Body setae moderately numerous, more conspicuous posteriorly on abdomen and ventrally on thorax. Head uniformly pale orange, approximately as broad as long, broadest at the middle, with flattened area on each posterolateral surface, the sides nearly straight and convergent behind the middle. Frontal suture discernible throughout its length, narrow. Endocarina distinguishable, approximately one-half as long as frons. Head with numerous short, slender setae. Ocellus not discernible. Antenna not overhung by extension from frons. Labral tormae moderately long and strong. Mandible with two apical teeth and subapical dorsal projection; mola with an oblique, transverse ridge. Labial palpus with two articles. Prementum with several elongate setae near base of palpi. Premental sclerite not distinguishable. Submentum with several pairs of moderately long setae. Dorsal surface of maxilla without a transverse band of setae at middle. Stipes with many setae dorsally and ventrally.

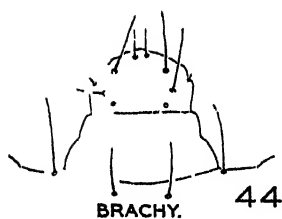
## EXPLANATION OF PLATE IV

Fig. 43. Lateral view of *Cimberis pilosus*,  $\times 28$ . Fig. 44. Labrum and clypeus of *Brachytarsoides* sp., near *sticticus* (Fullerton, Md.),  $\times 160$ . Fig. 45. Epipharynx of *Euparius marmoreus*,  $\times 50$ . Fig. 46. Labrum and clypeus of *Toxonotus fascicularis*,  $\times 50$ . Fig. 47. Epipharynx of *Ormscus* sp. (Coconut Grove, Fla., in *Tamarindus indica* pod),  $\times 95$ . Fig. 48. Same of *Anthribus albinus*,  $\times 50$ . Fig. 49. Same of unknown genus (see p. 508),  $\times 100$ . Fig. 50. Same of *Toxonotus fascicularis*,  $\times 50$ . Fig. 51. Same of *Discotenes nigrotuberculata*,  $\times 115$ . Fig. 52. Same of *Cimberis pilosus*,  $\times 85$ .



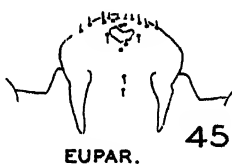
CIMBERIS

43



BRACHY.

44



EUPAR.

45



TOXON.

46



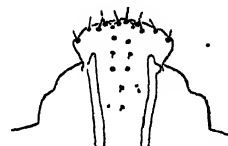
ORMIS.

47



ANTHR.

48



GENUS UNK.

49



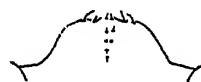
TOXON.

50



DISCOT.

51



CIMB.

52

Pronotum emarginate, with setae moderately numerous. Legs short, clearly biarticulate, the apical article of prothoracic leg as broad as long.

Setae more numerous and longer dorsally on posterior abdominal segments. Asperities very fine. Anus ventro-terminal.

Width of head: up to 2.3 mm.

*A. albinus* (L.). Falster, Denmark, branch of linden. Received from Meinert.

## VI. Genus *Neanthribus* Jordan

*Neanthribus* Jordan, Biologia Centrali-Americana, v. 4, pt. 6, p. 341, 1906.

*Pseudanthribus* Pierce, U. S. Natl. Mus. Proc. 77 (art. 17): 24, 1930. (New synonymy.) *Anthribus cornutus* Say (Descriptions of New Species of Curculionides of North America, etc., p. 4, 1831, New Harmony, Ind.) is hereby designated as type of *Pseudanthribus* Pierce (l. c.). Adult specimens of *Neanthribus championi* Jordan (l. c., p. 342), type of *Neanthribus* by original designation, have been compared with specimens of *P. cornutus* (Say) and the two species are considered to be congeneric.

Larvae of *Neanthribus* agree with those of *Anthribus* in the important characters which are: Pigmentation of frons confined to a transverse, marginal darkening. Labrum with 10 or more than 10 pairs of setae. Epipharynx with more than seven pairs of setae, the median spines transversely or anteriorly directed. Maxillary palpus with three articles. Dorsal surface of mala without tuft of setae. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval.

Width of head: up to 2.5 mm.

The principal differences which distinguish larvae of *Neanthribus* from those of *Anthribus*, as indicated in the key, are: Mala narrower apically. Lacinia twice as long as wide at base.

*Neanthribus* sp. Venice, La., February 19, 1945, in Virginia creeper (*Psedera*) vine, H. A. McPherson. Boothville, La., February 21, 1945, in Virginia creeper vines, D. W. Whitmire.

*Neanthribus* sp. Mexico, January 16, 1946, stem *Merostachys racemiflora*, G. F. Callaghan, E. D. Algert, and P. X. Peltier.

## VII. Genus *Toxonotus* Lacordaire

(Figs. 9, 37, 41, 46, 50)

*Toxonotus* Lacordaire, Histoire naturelle des insectes. Genera des Coléoptères, Paris, v. 7, p. 575, 1866.

Labrum with approximately 20 pairs of setae. Epipharynx with approximately 40 setae on each side, the median spines short, the majority of them directed backwards. Mandible without strong projection on dorsal inner margin, the mola without oblique ridge. Maxillary palpus with three articles. Mala less broadly rounded than in *Anthribus*. Lacinia twice as long as broad at base. Dorsal surface of mala, immediately above base of lacinia, with a brushlike tuft of setae.

Width of head: 2.0 mm.

*T. fascicularis* (Schoen.). Big Pine, Fla., 1919, dead twig *Rhacoma crossopetalum*, Schwarz and Barber. Big Pine Key, Fla., April 6, 1945, dead limb *Coccoloba floridana*, O. B. Link.

VIII. Genus *Meconemus* Imhoff

*Meconemus* Imhoff, (Labram, David, and Imhoff, Ludwig) Singulorum Generum Curculionidum, Basel, No. 42, 1842.

Labrum with four pairs of setae. Epipharynx with seven pairs of setae. Labial palpus with two articles. Maxillary palpus with three articles. Mala rounded, with numerous setae. Lacinia very short, acute. Pronotum with lateral, rodlike thickening. All spiracles bicameral, the air tubes very short. Legs elongate, with two distinct articles. Ninth abdominal segment with three small, flattened, fleshy protuberances on dorsal surface, near posterior margin, one median and one each side. Proventriculus with bands of prominent asperities.

Larva moderately large and robust, slightly thicker anteriorly. Paired sclerite of pronotum very lightly pigmented, remainder of body white. Body setae numerous, more conspicuous ventrally on thoracic segments. Head not pigmented except for small, triangular, pigmented area anteriorly on frons, with flattened area on each posterolateral surface, as broad as long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture hardly discernible. Endocarina not heavily pigmented, more than one-half as long as frons. Head with moderately numerous short to moderately long setae. Ocellus small, indistinct. Antenna not overhung by extension from frons. Labral tormae short, stout. Posterior pair of median spines of epipharynx transversely arranged. Mandible apically unid, with strong, rounded mola. Labial palpus with two articles, the basal article distinct, the two palpi nearly contiguous at base. Sternum with one pair of elongate setae. Premental sclerite present. Submentum with approximately eight pairs of setae.

Pronotum emarginate, nearly divided in the middle line, with setae short and sparse. Air tubes of thoracic spiracle without annulations, the air tubes very short, scarcely extending beyond margin of peritreme.

Air tubes of abdominal spiracles very short, without annulations. Asperities hardly discernible except a transverse band of strong asperities ventrally on abdominal segment IX.

Width of head: up to 2.5 mm.

*M. infuscatus* (Fähr.). Nicholson, Miss., December 26, 1944, dry branch *Liquidambar*, L. V. France. Nicholson, Miss., January 25, 1945, dry wood *Halesia carolina*, G. J. Rau. Nicholson, Miss., February 10, 1945, dead limb *Carpinus* on ground, M. Gordon.

The identification of these larvae as *Meconemus* is inferred from their size and the locality at which they were collected. The other genera occurring in Mississippi and containing species as large as this are already known.

A proventriculus similar to that reported by Gardner (1936) for a larva of *Aulotropis* Jordan is present in larvae of the above-described species. Gardner also reports that the ninth abdominal segment of the larva of *Aulotropis* bears a rounded, fleshy protuberance at each posterior angle, a condition very suggestive of that here noted for *Meconemus* and *Discolenes*. It seems quite likely, therefore, that these three genera are closely related.

IX. Genus *Discotenes* Imhoff

(Figs. 15, 20, 29, 51)

*Discotenes* Imhoff, (Labram, David, and Imhoff, Ludwig) *Singulorum Generum Curculionidum*, Basel, No. 51, 1841.

Dorsal surface of abdominal segment IX with three flattened fleshy protuberances near posterior margin, one median and one each side. Labrum with four pairs of setae. Head capsule with flattened area on each posterolateral surface. Hypopharyngeal sclerite absent. Maxillary palpus with two articles. All spiracles small, bicameral. Legs very short, each with one article. Proventriculus with bands of prominent asperities.

Larva small, moderately robust anteriorly, bluntly wedge-shaped posteriorly. Body without pigmented sclerites. Body setae numerous, more conspicuous ventrally and posteriorly. Head scarcely pigmented, slightly longer than broad, broadest slightly before the middle, the sides nearly straight and convergent behind the middle. Frontal suture indistinguishable posteriorly, indistinct anteriorly. Endocarina absent. Head with moderately numerous short, slender setae. Antenna not overhung by extension from frons. Labral tormac colorless, elongate. Epipharynx with four anterolateral and four anteromedian setae and four median spines, the posterior pair of spines transversely arranged; a few asperities near middle of epipharynx. Mandible gouge-shaped apically, without distinguishable mola. Labial palpus with two articles, basal article short, indistinct, without discernible seta, the palpi moderately widely separated. Prementum with three pairs of elongate setae. Premental sclerite absent. Submentum with approximately 10 pairs of setae on the median area. Stipes and mala with moderately numerous setae dorsally and ventrally; mala bluntly pointed.

Pronotum gradually but distinctly emarginate, with vague lateral rodlike thickening and with setae rather short and sparse. Air tubes of thoracic spiracle without annulations, the length of each distinctly less than greatest diameter of broadly oval peritreme.

Air tubes of abdominal spiracles without annulations, the length of each less than the diameter of subcircular peritreme.

Width of head: up to 0.68 mm.

*D. nigrotuberculata* (Schffr.). Brownsville, Tex., in *Acacia*, Hopkins, U. S. No. 10631d.

## X. Genus unknown

Head slightly longer than broad, with flattened area on each posterolateral surface. Hypopharyngeal sclerite hardly discernible, not projecting. Labrum with approximately 10 pairs of setae. Labral tormac stout, subtriangular. Epipharynx with three anterolateral and four anteromedian setae, and 8 to 10 median spines. Epipharynx with longitudinal, subparallel patches of asperities near middle. Labial palpus with two articles, the basal article with a distinct seta. Prementum with approximately 10 setae. Maxillary palpus with three articles. Stipes with numerous setae dorsally and ventrally. Lacinia stout. Mala pointed, with moderately numerous setae dorsally and

ventrally. Pronotum without lateral, rodlike thickening. All spiracles bicameral. Legs clearly biarticulate.

Width of head: up to 1.05 mm.

College Park, Md., October 18, 1942, bark of dead oak, W. H. Anderson.

#### XI. Genus unknown

Head as broad as long, with flattened area on each posterolateral surface. Hypopharyngeal sclerite very stout, the anterior margin straight. Labrum with four pairs of setae. Labral tormae rather short, slender, subtriangular. Epipharynx with three anterolateral and four anteromedian setae and four median spines. Both pairs of median spines transversely arranged. Epipharynx with central patch of moderately distinct asperities. Labial palpus with two articles, the basal article with numerous short, slender asperities apically. Prementum with one pair of elongate setae and numerous short, slender asperities. Mentum and submentum vaguely distinguishable. Submentum with several pairs of setae. Maxillary palpus with three articles. Lacinia stout. Mala apically acute and with moderately numerous setae dorsally and ventrally.

Thoracic spiracle bicameral, the air tubes indistinctly annulated. Legs clearly biarticulate.

Abdominal spiracles bicameral, the length of each air tube subequal to diameter of subcircular peritreme, the air tubes with a few indistinct annulations. Asperities more distinct in two patches, one above, the other below the spiracle on abdominal segments I to IV.

Width of head: up to 1.0 mm.

Mount Pleasant, S. C., August 8, 1944, dead wood of *Ficus*, M. J. Mallia. Nicholson, Miss., January 30, 1945, dry sprout *Persea* sp., M. Gordon. Picayune, Miss., December 29, 1944, dry pecan branch, H. A. McPherson and L. V. France.

A larva of approximately the same size and related to the larvae described above is in the collection: Mexico, December 21, 1937, dry mesquite wood. It differs in several features, the most important being epipharynx with approximately 15 anterolateral setae and the apex of prothoracic leg modified. The modification of the leg suggests the condition, described by Gardner (1936), found in larvae of *Tropideres*. The latter genus does not occur in the United States (Wolfrum, 1938). It is replaced by *Goniocloeus* Jordan.

#### XII. Genus *Piesocorynus* Dejean

(Figs. 6, 7, 12, 16, 36)

*Piesocorynus* Dejean, Catalogue des Coléoptères, ed. 3, p. 257, 1837.

Head with a flattened area on each posterolateral surface. Labrum with four pairs of setae. Epipharynx with four median spines. Posterior pair of median spines longitudinally arranged. Labial palpus with two articles. Prementum with four or five pairs of setae. Maxillary palpus with three articles. Mala subacute apically. Anterior margin of pronotum not emarginate. Pronotum without lateral, rodlike thickening. All spiracles bicameral. Legs elongate, clearly



biarticulate. Anus ventro-terminal. Abdominal segment IX usually with several strong, hook-shaped asperities on each side of eusternum.

Larva moderately large, robust, bluntly wedge-shaped posteriorly. Body setae moderately numerous, inconspicuous except dorsally on abdominal segments VI to VIII and ventrally on thorax. Head as long as or slightly longer than broad, broadest clearly before the middle, the sides nearly straight and convergent behind the middle. Frontal suture distinguishable throughout its length. Endocarina indistinct, short. Head with moderately numerous, short to moderately long setae. Ocellus indistinct. Antenna small, scarcely overhung by extension from frons. Labral tormae moderately stout and long. Epipharynx with three anterolateral and four anteromedian setae, and with subparallel, longitudinal patches of slender asperities near the middle. Mandible with indistinct, flattened, smooth mola. Submentum with several pairs of setae. Stipes and mala with moderately numerous setae dorsally and ventrally.

Pronotum with moderately numerous setae. Air tubes of thoracic spiracle slender, with annulations, the length of each less than one-third the greatest diameter of broadly oval peritreme.

Length of each air tube of abdominal spiracles approximately one-third the diameter of subcircular peritreme. Setae numerous on abdominal areas.

Width of head: up to 1.7 mm.

*P. mixtus* Lec. University Park, Md., winter 1944-45, in fungus, *Nummularia tinctor*, growing in bark of dead maple, W. H. Anderson. The mature larvae excavate pupal cells between the bark and the wood in the fall and transform to prepupal larvae which overwinter. Adults appear in April or May.

*Piesocorynus* sp., probably *dispar* (Gyll.). Data as above. Mature larvae excavate pupal cells in the wood, plugging the hole with wood fibers. Adults of *dispar* were collected on the fungus but none was reared.

*Piesocorynus* sp. College Park, Md., October 18, 1942, bark of dead oak, W. H. Anderson.

*Piesocorynus* sp. Nicholson, Miss., December 12, 1944, oak stump, A. L. Williamson. Nicholson, Miss., January 13, 1945, dead limb of red oak, H. A. McPherson. Nicholson, Miss., January 22, 1945, rotting stump *Carpinus caroliniana*, G. J. Rau. Picayune, Miss., December 16, 1944, dead, dry oak wood, A. L. Williamson and L. V. France.

### XIII. Genus unknown

(Fig. 49)

Head as long as broad, with flattened area on each posterolateral surface. Hypopharyngeal sclerite well developed. Labrum with four pairs of setae. Labral tormae long, slender. Epipharynx with three anterolateral and four anteromedian setae and four median spines. Posterior pair of epipharyngeal spines longitudinally arranged. One pair of peg-shaped sensilla in front of, the other behind the anterior pair of spines. A few slender asperities arranged in two longitudinal, subparallel patches near middle of epipharynx. Labial palpus with

two short articles, the apical article as broad as long, the basal article with a seta. Prementum with two pairs of setae. Submentum with one or two pairs of setae on median area, each lateral area with approximately five setae. Maxillary palpus with two articles. Stipes with moderately numerous setae dorsally and ventrally. Lacinia stout. Mala acute, with moderately numerous setae.

Anterior margin of pronotum not emarginate. Thoracic spiracle bicameral, the air tubes slender, each nearly as long as greatest diameter of broadly oval peritreme, with numerous annulations. Legs clearly biarticulate.

Abdominal spiracles bicameral. Abdominal segment IX without fleshy protuberances.

Width of head: up to 0.9 mm.

University Park, Md., August 27, 1944, in fungus, *Nummularia tinctor* on dead maple, W. H. Anderson. It is possible that the larvae described above belong to the genus *Eusphyrus* Leconte (1876, p. 399).

#### XIV. Genus *Ormiscus* Waterhouse

(Figs. 27, 47)

*Ormiscus* Waterhouse, Ann. and Mag. Nat. Hist. 16: 37, 1845.

Head with flattened area on each posterolateral surface. Hypopharyngeal sclerite strong. Labrum with four pairs of setae. Anterior and posterior pairs of peg-shaped sensilla on epipharynx usually close together, situated approximately between the spines of anterior pair of median spines, the posterior pair of spines transversely arranged. Labial palpus with two articles, the apical article nearly twice as long as width at base. Submentum with one pair of setae on median area. Maxillary palpus with two articles. Legs very short, often hardly discernible. Abdominal segment IX without fleshy protuberances.

Larva small, moderately slender, of nearly equal thickness throughout, not wedge-shaped posteriorly. Anterior margin of pronotum straight, the pronotum as long in the middorsal line as it is laterally. Body without pigmented areas. Body setae numerous, rather conspicuous ventrally and posteriorly. Head only very lightly pigmented, slightly longer than broad, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture indistinct but visible throughout its length. Endocarina present, colorless, approximately one-third as long as frons. Head with moderately numerous, moderately long to long setae on anterior half, posterior half without setae. Antenna somewhat overhung by extension from frons. Labral tormae moderately long and slender. Epipharynx with three anterolateral and four anteromedian setae, and usually with a few hardly discernible asperities. Mandible with two apical teeth, the mola narrow, smooth. Basal article of labial palpus without discernible seta but with slender apical asperities. Premental sclerite present, narrowly interrupted in the middle. Prementum with one pair of elongate setae. Stipes with more than 10 setae dorsally and ventrally. Mala apically pointed, with moderately numerous setae dorsally and ventrally.

Pronotum with numerous setae. Thoracic spiracle bicameral, the air tubes without annulations, the length of each approximately one-half that of the greatest diameter of broadly oval to subcircular peritreme.

Prodorsum of typical abdominal segments with a short, transverse ampullalike protuberance, usually somewhat more prominent on segments IV and V. Abdominal spiracles bicameral, the air tubes without annulations, the length of each air tube usually nearly as great as the greatest diameter of broadly oval to subcircular peritreme. Abdominal areas with numerous setae. Asperities hardly discernible. Anus terminal.

Width of head: up to 0.76 mm.

Description based upon numerous larvae which represent several species, only one of which has been identified, namely, *O. angulatus* (Suffr.): Santiago de las Vegas, Cuba, March, 1905, in husk, immediately about the seeds of *Artocarpus communis*, G. Dimmock. The unidentified larvae, mainly from the Southeastern States, were collected in various hosts, nearly always in dead twigs.

*Ormiscus angulatus* was originally described by Suffrian (1870, p. 187) in the genus *Tropideres* Schoenherr (1823, p. 1135). It was transferred to *Ormiscus* by Wolfrum (1930). If this generic assignment is correct and no specific synonymy is involved, the species *Ormiscus angulatus* Pierce (1930, p. 6) is without a name.

#### XV. Genus *Platyrhinus* Clairville

*Platyrhinus Clairville*, Entomologie Helvetique ou Catalogue des Insectes de la Suisse (plates by J. R. Schellenberg), Zurich, p. 112, 1798.

Head without flattened area on each posterolateral surface, the sides rounded behind the middle. Labrum with four pairs of setae. Epipharynx with three anterolateral setae. Posterior pair of median spines of epipharynx longitudinally arranged. Labial palpus with two articles. Maxillary palpus with three articles. All spiracles bicameral, the air tubes very short, the peritreme broadly oval.

Larva large, robust, tapering posteriorly, strongly curved through abdominal segments V and VI. Anterior margin of pronotum not emarginate. Paired sclerite of pronotum light brown. Body setae moderately numerous, more conspicuous ventrally on thoracic segments. Head brown, slightly broader than long, broadest at the middle, rounded posteriorly. Frontal suture distinct throughout its length, angulate posteriorly. Endocarina present, less than one-half as long as frons. Setae on head moderately numerous. Ocellus distinct. Antenna nearly completely overhung by extension from frons. Labral tormac moderately long, stout. Epipharynx without sclerite anteromedially, with four anteromedian setae. Mandible with two apical teeth. Outer surface of mandible with two setae. Mola large, rounded, smooth. Labium moderately small. Prementum with one pair of setae. Premental sclerite present. Submentum with several pairs of setae. Stipes and mala with moderately numerous setae dorsally and ventrally; mala bluntly pointed apically.

Pronotum with setae moderately numerous. Legs clearly biarticulate, the apical article bluntly conical, each article with elongate setae near apex.

Setae on abdominal areas moderately numerous. Anus terminal. Asperities inconspicuous, sparse.

Width of head: up to 3.0 mm.

*P. resinosus* (Scop.). Sjaelland, Denmark, in dead beech, Meinert. Sjaelland, Denmark, August 5, 1906, in black fungus on beech, E. Rosenberg. (This latter lot is identified as *P. latirostris* (F.), a synonym of *P. resinosus*.)

#### XVI. Genus *Eurymycter* Leconte

*Eurymycter* Leconte, Amer. Phil. Soc. Proc. 15 (96): 394, 1876.

Head light orange, smoothly rounded laterally, without flattened areas. Labrum with four pairs of setae. Epipharynx with approximately 10 anterolateral setae. Posterior pair of median spines of epipharynx transversely arranged. Labial palpus with two articles. Maxillary palpus with three articles. All spiracles bicameral. Air tubes of thoracic spiracle very short, the length of each about one-half as great as the diameter of peritreme.

Larva moderately large, moderately robust, slightly wedge-shaped through abdominal segment IX, the dorsal surface of abdominal segment IX with two parallel, longitudinal grooves. Anterior margin of pronotum straight. Paired sclerite of pronotum light orange. Body setae moderately numerous. Head as broad as long, broadest at the middle, oval posteriorly. Frontal suture indistinct posteriorly. Endocarina present, not pigmented, less than one-half as long as frons. Head with numerous short to moderately long setae. Ocellus moderately prominent. Antenna nearly overhung by extension from frons. Labral tormae short to moderately long. Epipharynx with four anteromedian setae, without asperities. Mandible with two apical teeth, the mola straight, narrow, smooth. Outer surface of mandible with at least four setae. Labium small. Prementum with one pair of setae. Premental sclerite short, interrupted in the middle line. Submentum with several pairs of setae. Stipes with several setae dorsally and ventrally. Mala pointed, with moderately numerous setae dorsally and ventrally.

Pronotum with numerous setae. Legs clearly biarticulate, the apical article bluntly attenuate, each article with several elongate setae.

Anus ventro-terminal. Asperities abundant and moderately conspicuous, at least dorsally.

Width of head: up to 2.2 mm.

*E. fasciatus* (Oliv.). Plummers Island, Md., February 10, 1910, in old sycamore log in gallery below knob of hard black fungus on surface, H. S. Barber. Adults were not reared but association of adults of *fasciatus* with the same kind of fungus leads to the belief that the identification of the larvae is correct. Data on adult specimens of this species, without associated larvae, indicate that *Sassafras* and *Betula* also may serve as hosts.

#### XVII. Genus *Euparius* Schoenherr

(Figs. 11, 14, 18, 25, 32, 42, 45)

*Euparius* Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Head uniformly roddish brown, subcircular, without flattened areas. Labrum with four pairs of setae. Posterior pair of median spines of epipharynx arranged longitudinally. Epipharynx with small sclerite between and in front of anterior pair of median spines. Labial palpus

with one article. Maxillary palpus with two articles. All spiracles bicameral, the length of each air tube of the abdominal spiracles usually less than the diameter of subcircular peritreme.

Larva moderately large, rather slender, of nearly equal thickness throughout, bluntly wedge-shaped posteriorly. Pronotum with paired brownish-yellow sclerite. Body setae moderately numerous. Head as broad as or broader than long. Frontal suture narrow, distinct throughout its length, incomplete, but ending laterad of antenna. Endocarina absent. Head with numerous short to moderately long setae arranged in vague rows at least posterolaterally. Ocellus prominent. Antenna scarcely overhung by extension from frons. Labral tormae stout, moderately long. Epipharynx with three anterolateral and four anteromedian setae. Mandible with two apical teeth and moderately prominent projection near middle of dorsal inner margin. Mandibular mola narrow, straight, without transverse grooves. Outer surface of mandible with five setae. Labium small, the palpi touching at base, each palpus directed slightly dorsally. Prementum narrow, with a single elongate seta on each side. Premental sclerite distinct. Submentum with several pairs of elongate setae. Stipes and mala with moderately numerous setae dorsally and ventrally, mala acute apically.

Pronotum with numerous setae. Air tubes of thoracic spiracle extending from posterior margin of peritreme, each air tube shorter than diameter of oval peritreme, indistinctly annulated. Legs moderately long, with two articles, each article with several elongate setae.

Abdominal areas with numerous setae. Anus terminal. Asperities moderately conspicuous along anterior margin of dorsal body folds.

Width of head: up to 1.6 mm.

The first-stage larva agrees with the description given above in the principal characters. It differs in that the head is lighter in color; the sclerite is not discernible on epipharynx; the diameter of peritreme is much shorter than the length of the air tubes; the mandible bears only two setae. An egg-tooth is present immediately above the spiracle on abdominal segments I to III.

*E. marmoreus* (Oliv.) Numerous larvae from various localities in the Southeastern States. The larvae are from a variety of woody plants but probably always associated with fungus.

### XVIII. Genus *Brachytarsoidea* Pierce

(Figs. 3, 4, 10, 31, 44)

*Brachylarsoidea* Pierce, U. S. Natl. Mus. Proc. 77 (art. 17): 29, 1930.

Prodorsum not prominent on abdominal segments and not plicate. Head scarcely pigmented, without flattened areas. Labial palpus with one article. Maxillary palpus with two articles. Thoracic spiracle bicameral, abdominal spiracles unicameral, the air tubes distinctly annulated.

Larva small, moderately slender. Pronotum without pigmented sclerite. Body setae moderately numerous. Head as broad as or slightly broader than long, broadest at the middle, rounded posteriorly. Frontal suture indistinct. Endocarina absent. Head with moderately numerous short to moderately long setae. Ocellus prominent. Antenna

not overhung by extension from frons. Labrum with four pairs of setae. Labral tormae stout, moderately long. Epipharynx with two or three anterolateral and four anteromedian setae and four median spines; without asperities. Mandible with two apical teeth and with rounded, transversely grooved mola. Labium small, the palpi close together. Prementum narrow, with one or with five or six pairs of setae. Premental sclerite complete. Submentum with two or more pairs of elongate setae. Stipes and mala with several setae dorsally and ventrally. Apex of mala usually with a short, membranous projection which bears setae.

Pronotum with numerous setae. Length of each air tube of thoracic spiracle subequal to or less than greatest diameter of broadly oval peritreme. Legs short, usually with two indistinctly separated articles, each article bearing elongate setae.

Length of air tube of abdominal spiracles subequal to or slightly greater than diameter of broadly oval to subcircular peritreme. Abdominal areas with numerous setae, the setae sparser on pleural, pedal and eusternal areas than dorsally. Anus terminal. Asperities absent or inconspicuous.

Width of head: up to 0.93 mm.

*B. alternatus* (Say). Vienna, Va., June 24, 1943, in fungus, *Cystopus*, on *Ipomoea*, J. C. Bridwell.

*B. sticticus* (Boh.). Victoria, Tex., in nuts, J. C. Bridwell.

*Brachytarsoides* sp., near *sticticus* (Boh.). Fullerton, Md., September 22, 1943, in smut on corn, Mohr and Graham.

*B. limbatus* (Say). Dallas, Tex., August 16, 1906, in stems *Sideranthus*, W. D. Pierce.

*Brachytarsoides* sp., near *limbatus* (Say). Burlington, Ore., August 18, 1944, in flower heads of *Helenium autumnale*, E. I. Smith, G. F. Prole and C. G. Anderson.

*Brachytarsoides* sp., probably *vestitus* (Loc.). Columbus, Tex., from *Helenium microcephalum*, Hunter Note No. W-122 I-1.

## XIX. Genus *Araecerus* Schoenherr

(Figs. 13, 23, 26, 35)

*Araecerus* Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Prodorsum on abdominal segments I to V prominent, with a transverse row of short, longitudinal plicae. Head light yellow, without flattened areas. Labial palpus with one article. Maxillary palpus with two articles. Thoracic spiracle bicameral, abdominal spiracles unicameral, the air tubes short, without annulations. Legs absent, replaced by clusters of setae.

Larva moderately small, moderately slender, tapering slightly anteriorly. Pronotum without pigmented sclerite. Body setae numerous, particularly on ventral surface of thoracic segments. Head as broad as or slightly broader than long, broadest near the middle, rounded posteriorly. Frontal suture distinguishable throughout its length, indistinctly complete anteriorly. Endocarina absent. Head with numerous short to moderately long setae. Ocellus prominent. Antenna somewhat overhung by extension from frons. Labrum with four pairs of setae. Labral tormae moderately long. Epipharynx

with three anterolateral and four anteromedian setae and four median spines; without asperities. Mandible with two apical teeth, the dorsal tooth shorter and with projection near base. Mandible with nearly straight, flattened mola. Labium small, each labial palpus with a seta near base on inner surface. Prementum narrow, with two pairs of moderately long setae, and with asperities laterally. Premental sclerite interrupted in the middle. Submentum indistinctly set off from mentum, with several pairs of setae. Stipes and mala with numerous setae dorsally and ventrally.

Pronotum with numerous setae. Peritreme of thoracic spiracle broadly oval.

Peritreme of abdominal spiracles subcircular. Abdominal areas with numerous setae. Anus terminal. Asperities short, colorless, pointed.

Width of head: up to 0.95 mm.

*A. fasciculatus* (Deg.), the coffee-bean weevil. This species is cosmopolitan in distribution and has been collected from a wide variety of hosts.

## XX. Genus *Choragus* Kirby

*Choragus* Kirby, Linn. Soc. London, Trans. 12: 447, 1818.

Prodorsum of typical abdominal segments normal. Head with flattened area on each posterolateral surface. Labial palpus with one slender article. Maxillary palpus with two articles. Pronotum without lateral, rodlike thickening. All spiracles unicameral. Anus terminal.

Larva small, moderately robust, not wedge-shaped posteriorly. Anterior margin of pronotum transverse. Body without pigmented areas. Body setae moderately numerous, longer on ventral surface of thorax. Head scarcely pigmented, as broad as long, broadest at the middle, the sides nearly straight and convergent behind the middle. Frontal suture not discernible posteriorly, vague anteriorly. Endocarina indistinct, nearly one-half as long as frons. Antenna somewhat overhung by extension from frons. Labrum with four pairs of setae. Labral tormae moderately long, only slightly pigmented. Epipharynx with three anterolateral and four anteromedian setae and four median spines, both pairs of spines transversely arranged. Epipharynx without asperities. Mandible with two apical teeth, the mola strong. Labial palpus without discernible seta. Premental sclerite absent or developed only laterally. Prementum with one pair of elongate setae. Submentum with four or more than four pairs of setae. Stipes with a total of approximately 15 setae dorsally and ventrally. Mala pointed apically, with moderately numerous setae dorsally and ventrally.

Pronotum with setae rather sparse and fine. Air tube of thoracic spiracle without annulations, the length of the air tube as great as the diameter of subcircular peritreme. Legs vestigial, each consisting of a very low, rounded projection which bears three elongate setae.

Air tube of abdominal spiracles without annulations, its length subequal to diameter of subcircular peritreme. Abdominal areas with the setae sparse. Asperities not discernible.

Width of head: up to 0.47 mm.

*C. zimmermanni* Lec. University Park, Md., January 30, 1944, associated with the fungus *Rosellinia purpureo-fusca* (Schw.) Ell. & Ev., on fallen dead maple branch, W. H. Anderson. University Park, Md., March 18, 1945, associated with the same fungus on fallen dead oak branch. The larvae overwinter in the wood, pupating in the early spring. Adults begin to emerge the latter part of April. Larvae of this or a closely related species were taken at Picayune, Miss., December 14, 1944, in dead wood of *Quercus nigra*, L. V. France.

From Gardner's description (1936), as *?Tropideres paviei* (Lesne) and (1937), it is apparent that the larva of *Deropygus curvatus* Jord. is related to that of *Choragus*.

### Subfamily *Cimberinae*<sup>6</sup>

#### XXI. Genus *Cimberis* Gozis

(Figs. 2, 8, 17, 22, 30, 38, 43, 52)

*Cimberis* Gozis, Soc. Ent. de France Bul. (6) 1: cxii, 1881.

Head free. Clypeus not distinguishable from frons. Epipharynx with one pair of peg-shaped sensilla. Mandible with low ventral process. Labial palpus with two articles. Maxillary mala subquadrate, the apical margin nearly straight.

Larva small, moderately slender, of nearly equal thickness throughout. Anterior margin of pronotum transverse. Pronotum with lightly pigmented sclerite. Body setae numerous, as conspicuous dorsally as ventrally. Head orange, broader than long, broadest behind the middle, only slightly rounded posteriorly, without flattened areas. Frontal suture distinct throughout its length, not obviously complete anteriorly. Endocarina present, nearly one-half as long as frons. Hypopharyngeal sclerite well developed. Ocellus moderately prominent. Antenna almost completely overhung by extension from frons, one of the minute processes peg-shaped. Labrum incompletely set off from clypeus. Anterior margin of labrum only slightly rounded. Labrum with four pairs of setae. Labral tormae absent. Epipharynx with two anterolateral and two anteromedian setae and four median spines, the median spines very short, the pairs well separated, the spines of posterior pair longitudinally arranged. Epipharynx without anteromedian pair of sensilla, without asperities. Mandible with two apical teeth, the mola triangular in surface view, moderately prominent. Prementum with one pair of elongate setae. Premental sclerite interrupted in the middle. Submentum with three pairs of setae. Stipes with two setae. Maxillary palpiger present, bearing three setae. Inner margin of mala, slightly behind angulate inner corner, with colorless, straight lacinia. Mala with moderately numerous setae dorsally and ventrally.

Setae on pronotum moderately numerous. Thoracic spiracle in mesothorax, the spiracle bicameral, the air tubes with numerous annula-

<sup>6</sup>This name, as well as the generic name *Cimberis*, is used here provisionally. The correct generic name for the species described by Leconte (1876, p. 2) as *Rhinomacer pilosus* is uncertain. It is apparent, however, that it does not belong in the genus *Rhinomacer* Fabricius (Species Insectorum, v. 1, p. 199, 1781), which is a monobasic genus having *curculionides* F. as type. The latter species is placed in the Pythidae.



tions, the length of each air tube subequal to or slightly greater than diameter of subcircular peritreme. Legs very small, conical or subconical.

Abdominal spiracles bicameral, the air tubes with annulations, the length of each air tube greater than the diameter of subcircular peritreme. Setae moderately numerous on abdominal areas. Anus terminal. Asperities inconspicuous and moderately sparse laterally and ventrally, not discernible dorsally.

Width of head: up to 0.67 mm.

The first-stage larva agrees with the description of the mature larva in the principal characters. It differs in that the maxillary palpiger is not distinguishable and the legs are blunt and do not bear setae. Short, conical, sclerotized egg-teeth are present laterally on mesothorax and metathorax and immediately above the spiracle on abdominal segments I to VIII.

*C. pilosus* (Lec.). Clifton, Va., May 9, 1933, from male cones of *Pinus virginiana*, J. C. Bridwell. Pupation takes place in trash on the ground.

The reasons for transferring the larva of *Cimberis* from the Curculionidae to the Anthribidae were pointed out by Emden (1938). The correctness of this transfer has been further substantiated by Ting (1940), who has studied the adults of this and related genera. Crowson (1944) believes that *Cimberis* and its relatives deserve family rank (Nemonychidae) = Doydirhynchidae). On the basis of the characters of the larvae which are at present considered diagnostic for the Anthribidae, it is more satisfactory to retain the group as a part of the latter family.

A larva which is closely related to that of *Cimberis* is in the collection and has been studied. It was collected on *Fascicularia bicolor* from Chile, February 1, 1936. It differs from the larva of *Cimberis* in several ways: Labrum is clearly distinct from clypeus; labral tornae are present, although short; epipharynx has three anterolateral and four anteromedian setae; premental sclerite is not interrupted; maxillary palpiger is not distinguishable. No known records of species from Chile, which are closely related to *Cimberis*, have been encountered so it is impracticable to attempt any speculation in regard to the identity of this larva.

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A CATALOGUE OF THE HESPERIOIDEA OF VENEZUELA, by E. L. BELL.  
Boletin de Entomologia Venezolana V, pp. 65-203, 1946.

So many species of South and Central American species of Hesperioidea have been described in the past few decades without the publication of adequate synoptic studies of the group that any effort to bring together comprehensive data for geographic areas or for taxonomic divisions must be regarded as a valuable and badly needed contribution. No one in North America is better qualified to do such work than Mr. Bell, who has already collaborated with Kenneth J. Hayward in Argentina, a leading South American authority, on a catalogue of the fauna of Ecuador.

The author apologizes for the many typographic errors in this publication, which are due to his having been given no opportunity to read the proof. He has prepared a mimeographed list of corrections. While such matters are a source of inconvenience, they can in no way reflect on the value of this catalogue. It lists all species originally described from Venezuela or later recorded from that country, and those represented by specimens bearing Venezuelan labels in the Collections of the American Museum of Natural History, The Academy of Natural Sciences in Philadelphia and the United States National Museum. Some records from the collection of Mr. René Lichy are also included. Indefinite records embracing the area, such as "Mexico to south Brazil," are omitted.

The catalogue lists genera with the genotype, the original reference and those of synonyms, and brief notes on generic characters. Species are listed with synonymy, distribution, and a short bibliography including references to principal works and to shorter papers which include figures. In each case a note indicates the location of figures of the insect or the genitalia. The catalogue also includes a bibliography and an index to scientific names—A. W. L.

THE PROVENTRICULUS OF *MACROBASIS*  
*UNICOLOR* KIRBY  
(Coleoptera: Meloidae)<sup>1</sup>

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The proventriculus of *Epicauta cinerea marginata* Fabr. (Meloidae) was described by Everly (1936). The descriptive terms employed by him are used as far as possible in the following description of the proventriculus of *Macrobasis unicolor* Kirby.

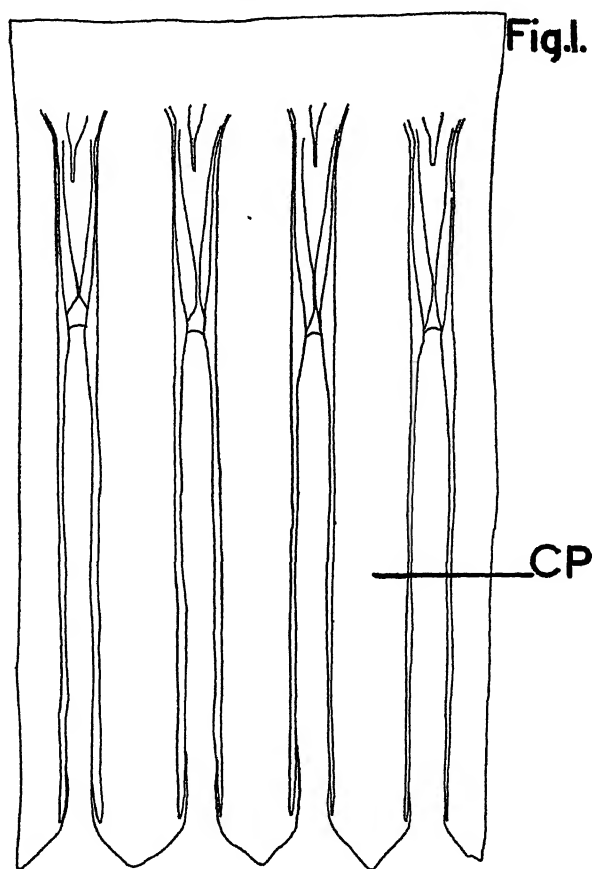


FIG. 1. Sclerotized intima of the proventriculus and oesophageal valve.

<sup>1</sup>Part of a thesis presented in accordance with the regulations for the degree of Master of Arts of the University of Western Ontario.

## MATERIALS AND METHODS

Adults of *Macrobasis unicolor* Kirby were collected from plants of Blue Cohosh (*Caulophyllum thalictroides* (L.) Michx.) at Wrightville, Quebec, June 8, 1939.

Whole mounts were prepared to show the sclerotized lining of the proventriculus flattened out and divested of connective tissue and muscles. The digestive tract of a beetle was removed from the body and was fixed, by means of pins through the crop and mid-gut, to a layer of wax in a Syracuse watch glass. The digestive tract was covered with water. The wall of the proventriculus was cut longitudinally

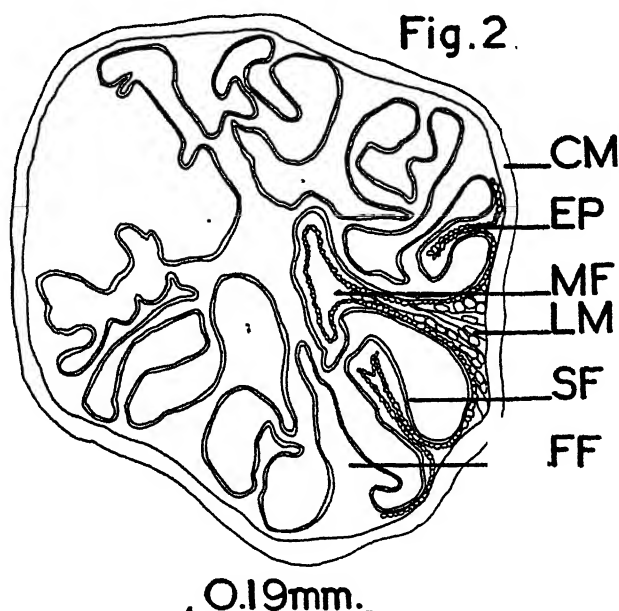


FIG. 2. Transverse section of the proventriculus.

## INDEX FOR FIGURES 1, 2 AND 3

- |                                     |                            |
|-------------------------------------|----------------------------|
| CM—circular muscle.                 | MF—mushroom-shaped fold.   |
| CP—projection of oesophageal valve. | MG—mid-gut.                |
| EP—epidermal layer.                 | OES—oesophagus.            |
| FF—finger-like fold.                | Oes. V.—oesophageal valve. |
| I—intima.                           | SF—secondary fold.         |
| LM—longitudinal muscle.             |                            |

with fine scissors and then the whole proventriculus was removed from the digestive tract and placed in a strong solution of potassium hydroxide. When the soft tissues had been dissolved the sclerotized intima was washed first with water, then with several changes of alcohols of increasing concentrations, then with absolute alcohol, and finally with xylol. It was then mounted in Canada balsam.

Serial transverse and longitudinal sections of the proventriculus were made. Material was fixed in Bouin's fixative, sectioned at  $10\mu$ , and stained with Haidenhain's haematoxylin and eosin.

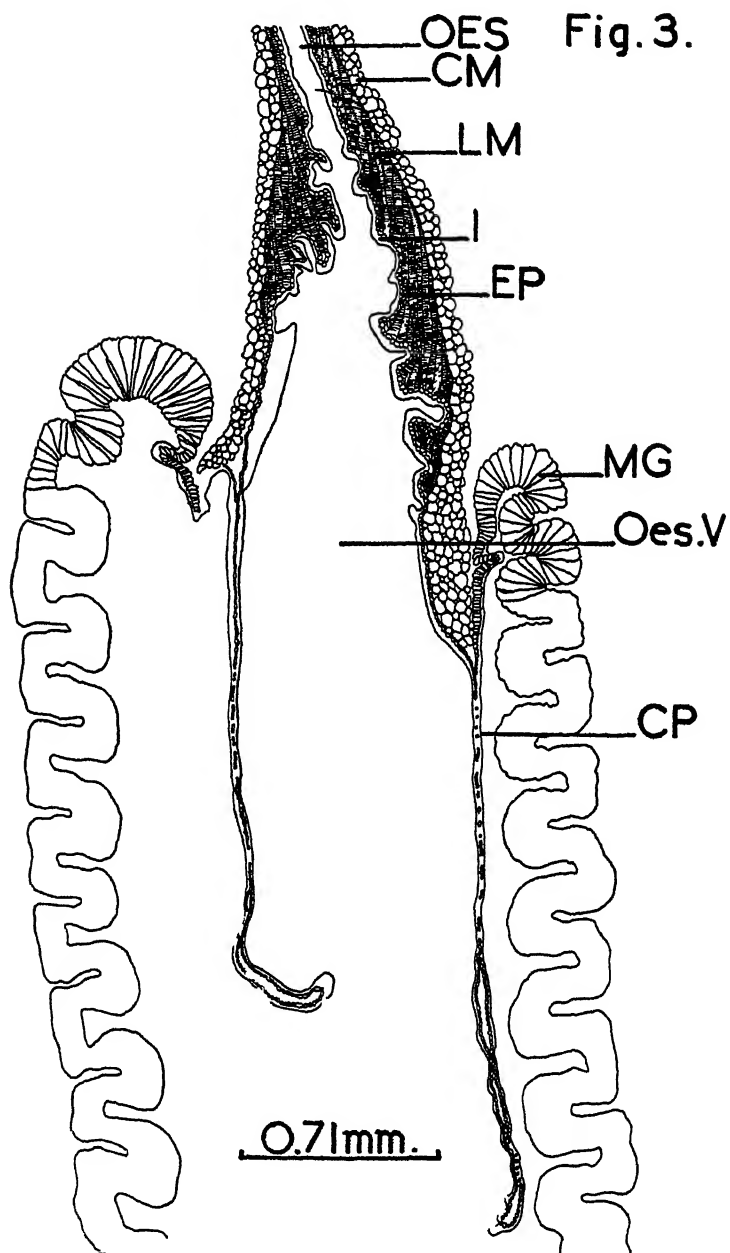


FIG. 3. Longitudinal section of the proventriculus and oesophageal valve.

## DESCRIPTION

In *Macrobasis unicolor* the oesophagus is a tube about 0.5 mm. in diameter. At its posterior end it widens into the proventriculus which is about 0.75 mm. in diameter. Posteriorly the proventriculus gives way to the oesophageal valve (fig. 3-Oes. V.) which projects into the mid-gut (fig. 3-MG).

The inner lining of the proventriculus is the thin, sclerotized intima (fig. 3-I). It is continuous with that of the oesophageal valve which extends into the mid-gut in the form of four separate projections (fig. 1, 3-CP). These are flat and are about 0.5 mm. wide. Their outer borders are more heavily sclerotized than their central portions. Beneath the intima is a layer of minute epidermal cells (fig. 2, 3-EP); they form a double layer in the projections of the oesophageal valve. Next to the epidermal layer, in the oesophagus and proventriculus, is the longitudinal muscle (fig. 2, 3-LM). It is four to six strands in thickness. Surrounding the longitudinal muscle is circular muscle (fig. 2, 3-CM) which is the widest in the region of the oesophageal valve.

The folds of the sclerotized intima of the proventriculus are similar in form to those found by Everly in *Epicauta cinerea*. Four of the folds are roughly mushroom-shaped in transverse section (fig. 2-MF). Their ends almost meet in the centre of the lumen of the proventriculus. Between these fold are four somewhat finger-shaped folds (fig. 2-FF) which are shorter than the mushroom-shaped folds. Alternating with, and smaller than, the mushroom-shaped and finger-shaped folds are eight secondary folds (fig. 2-SF).

The foregoing description indicates that the proventriculus of *Macrobasis unicolor* Kirby is similar in form to that of *Epicauta cinerea marginata*. Both species have a tubular proventriculus and an oesophageal valve consisting of four long projections ("finger-like" processes—Everly) extending into the mid-gut. The proventriculus shows sixteen folds: four large mushroom-shaped folds with twelve smaller folds, in groups of three, between them.

The writer wishes to express his appreciation to Dr. J. D. Detwiler, University of Western Ontario, for his aid and interest in this work.

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# OBSERVATIONS ON MEGARHINUS SPLENDENS WIEDEMANN WITH REFERENCE TO ITS VALUE IN BIOLOGICAL CONTROL OF OTHER MOSQUITOES<sup>1</sup>

(Diptera: Culicidae)

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*Megarhinus splendens* is a beneficial mosquito because its larvae eat other mosquito larvae. The adults do not bite man. Whether these facts justify the use of *M. splendens* by man to control mosquitoes is questionable, and it is this question which the writer tried to answer in his study of *M. splendens* in New Guinea and the Philippine Islands during 1944 and 1945.

According to Howard, Dyar, and Knab (1912), *Megarhinus* may have been the first mosquito to evolve larvae with prehensile mouthparts which are used in seizing prey. These writers did not speculate on how the purely predacious behavior of *Megarhinus* larvae originated, but perhaps it arose from cannibalism, which is still such an important phase of its predacity. *Megarhinus* females, to continue with Howard, Dyar, and Knab, do not bite because they cannot: a rigid labium prevents them from piercing and sucking; instead, they feed on flower nectar.

Although what they said no doubt applies, Howard, Dyar, and Knab did not specifically mention *Megarhinus splendens* because of its Eastern origin and distribution. Of its presence in the Orient, Edwards (1924) said that it is "widely-spread"; and Knight, Bohart, and Bohart (1944), without reservations, called it "ubiquitous," which, if true, makes it unnecessary to be specific about *M. splendens*' distribution. And if Knight, Bohart, and Bohart's key is reliable, it is impossible anyway to define accurately the location of *M. splendens* because of the confusion that exists in the taxonomy of *M. splendens*, *M. inornatus* Walker, and *M. subulifer* Doleschall of the Australasian region.

## FIELD OBSERVATIONS

Referring to its larval habitat, Edwards said that *Megarhinus splendens* "seems to be on the way to becoming a semi-domesticated species," meaning by this, that its breeding in artificial containers is increasing. Two years was, of course, too short a time for the writer to detect a trend; consequently, it can only be said that *M. splendens* larvae and pupae were collected from rain barrels in New Guinea, and from tree holes, bamboo stumps, leaf axils of the taro plant, tin cans,

<sup>1</sup>Contribution from the Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio.

<sup>2</sup>Formerly a member of the 41st Malaria Survey Unit, Army of the United States.

coconut shells, and pasteboard boxes in the Philippines. In only one instance was it found in a ground pool, and that was an abandoned latrine pit at Milne Bay, New Guinea. Only two of these habitats, tree holes and leaf axils, may be considered natural, or original, and so it is not difficult to follow the argument that *M. splendens* originally bred in tree holes, or to understand Edwards' statement that it is now switching to artificial containers.

Evidently the mortality of immature *Megarhinus splendens* is high in nature. For, while eight pupae were removed from the latrine pit, two was the highest number of fourth instar larvae and pupae ever found in any of the other seven habitats. Assuming from the laboratory records (Table I) of oviposition that *M. splendens* lays an average batch of 11 fertile eggs in a habitat, the presence, in most instances, of only one or two survivors suggests that from 82 per cent to 91 per cent of the immature mosquitoes die. According to Paine (1934), the larvae do not succumb readily to starvation and, in the fourth instar, they can live as long as seven weeks without food. Paine mentioned Notonectidae and Gerridae as preying on *M. splendens*, but these predacious bugs appear to be limited to ground pools and barrels, two types of habitats which do not figure largely in the natural distribution of the mosquito. Since starvation and natural enemies probably exert a negligible influence on the mortality of *M. splendens*, it seems plausible to attribute the high death rate of its larvae to cannibalism, and to consider *M. splendens* itself as its greatest enemy.

Compared with its prey, in this instance, *Armigeres obturbans* Walker, *Aedes albopictus* Skuse, and *Tripteroides*, *Megarhinus splendens* appears to be sparsely distributed. At Palo, Leyte, out of 76 bamboo stumps that were inhabited by mosquitoes, only three contained *M. splendens*. Although this is an isolated case, it still may be significant because it was observed during November, 1944, when conditions were best for most mosquito reproduction: that is, monthly rainfall totaled 23½ inches, and a large blood reservoir was available for the females of *M. splendens*' prey. Its significance rests in the possibility that this is a typical case of minimum predacity, that *M. splendens* is least effective when other mosquitoes are most abundant; because, as Paine suggested, the minimum predacity of *M. splendens* may be expected during the period of greatest rainfall, owing to the increase in the number of habitats and to the corresponding decrease in the chance that *M. splendens* might share a habitat with another mosquito. Such a suggestion is acceptable, provided that *M. splendens* has a lower reproductive capacity than its prey. And that condition was true in the following laboratory study.

#### LABORATORY STUDIES

The laboratory investigation of *Megarhinus splendens* was conducted at Milne Bay, New Guinea, early in 1944. Two pupae, taken from a rain barrel, produced a female on May 25, and a male on May 31. Both adults died June 27, a day after they had been moved to a new site 20 miles away. Thus, the female lived 33 days, and the male, 27 days. While these adults were alive, the temperature, as measured by a maximum-minimum thermometer, ranged from 72° to 88° F.; and



the noon humidity, as ascertained by a sling psychrometer, varied between 77 per cent and 89 per cent.

This pair of mosquitoes was placed in a cage 24 inches high, 18 inches long, and  $10\frac{1}{2}$  inches wide. Subsequent pairs, obtained from the latrine pit, were put in cages  $12 \times 13 \times 18$  inches and  $8 \times 8\frac{1}{2} \times 7\frac{1}{2}$  inches. Except for size, all cages were built alike. A wooden rectangular frame was nailed onto each end of a solid wood base; the framework was covered with mosquito netting which was extended at one end to form a sleeve, and the netting was held in place by wooden slats; finally, to provide additional support as well as a handle for carrying, the tops of the rectangular frames were connected by a piece of wood. Until a screened insectary could be built, the cages were kept in a pyramidal tent. In each cage the mosquitoes were furnished with a vial of 10 per cent sucrose in water, plugged with a cotton wick, as food, and a petri dish of water for oviposition.

Eggs were laid in the two largest cages. Copulation was not observed, but Paine, who saw one instance of it under natural conditions, described it as taking place during the day when the mosquitoes are at rest. The original female laid a total of 35 eggs in three batches during eight days (Table I). Except for the longer egg-laying period

TABLE I  
OVIPOSITION RECORD OF THE *Megarhinus splendens* FEMALE

Date Laid	Eggs	Incubation Period	Temperature
June 12, 1944.....	8	2 days	73-85° F.
June 15, 1944.....	15	2 days	75-83° F.
June 19, 1944.....	12	2 days	73-83° F.

and the presence of three distinct egg batches, this agrees with Banks' (1908) report that a confined *Megarhinus splendens* lays from 40 to 50 eggs in two days. Paine was unable to rear *M. splendens* in the laboratory, but he noted three natural ovipositions of 5, 10, and 16 eggs. The first batch of eggs was laid in the laboratory 18 days after the female emerged and 12 days after she was paired with a male, which was a much longer preoviposition period than the week that Banks assigned to it. The eggs were found lying singly on the water in the petri dish; the egg-laying was not witnessed, but Paine, who watched it in nature, said that the female drops the eggs one by one as she hovers in the air about two inches above the water. Shaped like chicken eggs in miniature, the eggs were white, and measured 0.6 times 0.4 mm. A very slight discoloration, so slight that it was thought that the eggs were sterile, took place just before hatching, due probably to the larval hairs which could be seen through the egg membrane. After incubating two days, the eggs hatched, and then usually in the late afternoon or early evening. Only one of the 35 eggs was sterile.

To find out if *Megarhinus splendens* eggs could withstand drying, half of a batch of eggs from another female was removed from water for

24 hours. The eggs that were left on water hatched in two days while those that were dried never hatched. Paine reported similar results.

The larvae were white in the first instar; they reddened in the second instar, and this color deepened in the final two instars. In the laboratory *Megarhinus splendens* often ate each other; therefore, it was necessary to isolate them to get an accurate count of the prey that were eaten. Because it was found with *M. splendens* in the latrine pit, and also because it was very abundant, *Culex pullus* Theobald was used as food. The *Megarhinus splendens* larvae hatched from the eggs that were laid June 12 (Table I). Each *M. splendens* larva was kept in a pint jar of water with 10 *Culex pullus* larvae; the *C. pullus* larvae that

TABLE II

AVERAGE NUMBER OF *Culex pullus* LARVAE EATEN BY A *Megarhinus splendens* LARVA

<i>M. splendens</i> instar	<i>C. pullus</i> instar				Total
	1	2	3	4	
1.....	5	3	.....	.....	8
2.....	12	3	.....	.....	15
3.....	.....	.....	.....	10	10
4.....	.....	.....	.....	58	58
Total.....	17	6	.....	68	91

TABLE III

DURATION OF *Megarhinus splendens* LARVAL INSTARS

Instar	Number of Days	Temperature
1.....	2	72-83° F.
2.....	3	73-85° F.
3.....	4	73-83° F.
4.....	21	68-86° F.

were eaten, or that died, were replaced daily. The average number of *C. pullus* larvae eaten by each of three *Megarhinus splendens* larvae was 91 (Table II).

On a diet of *Culex pullus* larvae in fresh rainwater, *Megarhinus splendens* spent an average of 30 days in the larval period (Table III). The lengths of the larval instars agree with those reported by Paine for field-collected larvae, except for the fourth instar which, Paine said, lasts eight days. And with the temperature varying between 68° and 89° F., three *M. splendens* spent an average of seven days in the pupal stage. Thus, the duration of *M. splendens*' life cycle, from adult to adult in the laboratory, was 57 days. By substituting Banks' figure of seven days for the pre-oviposition period, and Paine's average of eight days for the fourth instar, the life history occupies 33 days.

The adults from the above three *Megarhinus splendens* pupae were about two-thirds the size of their parents. Their small size implies that the larval diet was inadequate. Each *M. splendens* ate about 40 less mosquito larvae than would have been the case, from Paine's figures, had it been collected in the field. But why, in the presence of abundant food, the laboratory-reared *M. splendens* did not eat more larvae, is a question that was not answered by the laboratory observations.

#### USE IN BIOLOGICAL CONTROL

Within the tropics *Megarhinus splendens* shares habitats with *Aedes aegypti* Linnaeus and *A. albopictus*, carriers of dengue, and *A. scutellaris* Walker and *Armigeres obturbans*, vectors of filariasis, to name some of the important ones; and unquestionably *Megarhinus splendens* exerts some influence on the control of these harmful mosquitoes.

In an attempt to reduce the filarial rate by eliminating its carrier, *Aedes scutellaris*, Paine introduced *Megarhinus splendens* into Fiji from Java. Paine arrived at Fiji, February, 1931, with 238 *M. splendens* in different stages of development. The immature *M. splendens* were put in shaded barrels of water, where a natural infestation of other mosquitoes furnished the *M. splendens* with more food than they could eat; and upon emerging, the *M. splendens* females returned to lay their eggs in the barrels. From this source Paine collected immature *M. splendens*, and by April, 1932, he had liberated almost 3000 of them in various parts of Fiji. Except where it encountered dense jungle and dry weather, *M. splendens* spread rapidly; yet Paine estimated its reduction of *Aedes scutellaris* at only 5 per cent, and considered this reduction a justification for the expense of the introduction.

Paine borrowed the barrel technique for rearing *Megarhinus splendens* from Pemberton (Williams, 1931), who, earlier in 1929, had attempted to introduce *M. inornatus* into the Hawaiian Islands from New Britain. Pemberton started with 290 larvae and pupae, August, 1929; the larvae were placed in barrels of water in a forested region back of Honolulu, and by December of the same year, *M. inornatus* had spread to neighboring tree holes; six months later, *M. inornatus* had completely disappeared. In a letter (1946) to the writer Pemberton said: "My interest has since revived in this matter and some day we will try *Megarhinus splendens* and make liberations in a better place in Hawaii."

#### CONCLUSION

From the life history presented in this paper, however, it is believed that *Megarhinus splendens* will probably occupy a minor role in the elimination of mosquitoes. Its long life cycle and few offspring, when compared with *Aedes albopictus* (in the laboratory life cycle occupied about four weeks; approximately 60 eggs were laid in each batch), and its low survival rate tend to nullify the importance of *Megarhinus splendens* in biological control. Even the predacity of its larvae is of doubtful value since, in the form of cannibalism, it appears to be responsible for the high mortality rate among the immature *M. splendens*. Finally, Paine's estimate of a 5 per cent reduction of *Aedes scutellaris* by

*Megarhinus splendens* compares unfavorably with the results obtained by airplane-sprayed DDT. For, when 5 per cent DDT in a diesel oil solution was used at the rate of 500 gallons per square mile, the day-biting mosquito population (including *Aedes scutellaris*) on Palawan Philippine Islands, was reduced about 92 per cent, from an average of 26 to an average of two mosquitoes biting per hour, weather remaining the same.

## SUMMARY

After referring to some field observations of *Megarhinus splendens*, a laboratory study of the mosquito is given in detail. The use of the mosquito in biological control is reviewed and the conclusion is drawn that *M. splendens*' long life cycle, few offspring, and cannibalistic habit tend to render it ineffective as a means of controlling other mosquitoes.

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SIMULIDOS DE MEXICO, by L. VARGAS, A. MARTINEZ PALACIOS, and A. DIAZ NAJERA. Revista del Instituto de Salubridad y Enfermedades Tropicales. Vol. 7, No. 3, Septiembre, 1946. Biblioteca del Instituto de Salubridad y Enfermedades Tropicales, Mexico, D. F., Mexico. Price 75 cents.

This study of approximately 100 pages in size plus 25 pages of plates reports 77 species of Simuliidae for Mexico. Eighteen of these species are described as new. In previous papers Vargas has described 8 new species. These 77 species are distributed in 3 genera. Two genera are represented by one species each and they are *Cnephia ochracea* and *Gigantodax wrighti*. The remaining 75 species are placed in 9 subgenera of the genus *Simulium*. Two of the subgenera are new.

Keys based on male genitalia are given for the determination of genera, subgenera, and species. Many larvae are described for the first time and there are keys for the separation of 37 species. There is a brief account of the geographical distribution of these insects in Mexico.

The 25 pages of plates with 162 figures illustrate larval and adult characteristics for many species.

It should be pointed out that the regular publication in this journal of many papers on medical entomology by Dr. Vargas and others make it a necessary item in entomological libraries.—CARL E. VENARD.

## NOTES ON THE BREEDING HABITATS OF AEDES (STEGOMYIA) AEGYPTI (LINNEAEUS)<sup>1</sup>

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Attempts at control and eradication of *Aedes aegypti* (L.) are almost invariably based on the assumption that the mosquito is absolutely domestic, or at least is confined to man-made breeding places. Habitats described for larvae include all types of domestic containers, i. e., tin cans, buckets, bowls, etc., automobile tires, concrete drains, artificial pools, and dozens of other water-holding articles which have been created by mankind. That a program involving the complete eradication of *Aedes aegypti* by eliminating water-holding articles is not all-inclusive, even with adequate inspection of domestic premises and human modifications of natural situations, has been repeatedly proven in West Africa.

The subgenus *Stegomyia* of the genus *Aedes* appears to be best developed and to have reached its greatest diversification in West Africa. Evidence also indicates that *Aedes aegypti* probably originated in this section of the continent and has recently become domesticated. Once the domestic habits were established, trade routes opened paths for the dissemination of the mosquito until it was no longer restricted to its place of origin, but was established throughout the world. Since the spread of the species, variations from the original West African stock have begun to appear in other parts of its enlarged range. Whether the varieties are as efficient vectors of yellow fever as *A. aegypti* is open to question. *Aedes simpsoni* (Theo.), another West African *Stegomyia* which has been shown to be a vector of yellow fever, seems to be following the same pattern as did *Aedes aegypti* in becoming a domestic mosquito. *A. simpsoni* is still found frequently in natural situations as well as in domestic receptacles, a condition which is shared with *Aedes aegypti* in West Africa; however, domesticity appears to be far more highly developed in *A. aegypti* than in *A. simpsoni*.

During the course of an intensive *Anopheles gambiae* eradication program on the Gold Coast (British West Africa), larvae of *Aedes aegypti* were brought into the laboratory hundreds of times for identification. Most frequently the specimens were from oil-drums used by the natives for storing drinking water, from cooking utensils which were placed outdoors unused, or from discarded tin cans and bottles. However, larvae, which on identification proved to be *Aedes aegypti*, were also found in natural water holes in the ground. When this was first discovered, we were of the belief that *A. aegypti* was never found breeding in natural pools, and we therefore suspected that the larvae might be a closely related species. This led to the rearing of the next batch

<sup>1</sup>These notes were prepared at the suggestion of Dr. D. B. Wilson of the International Health Division, Rockefeller Institute. The mosquitoes were identified by Kenneth G. Gogel.

from similar situations and the imagos were found to conform in all respects to the description of *Aedes aegypti*.

From this time on, a close check was kept of breeding places in which larvae were found. They include (besides artificial containers, concrete drains, etc.) several natural situations, of which the rarest was in water in the axils of a banana tree. Other natural environments include tree holes, small ground pools in protected places, and rock pools.

Descriptions of breeding places of the species state that it is rare or impossible to find *A. aegypti* breeding in man-made places with mud sides and bottom, unless the larvae were accidentally deposited there by being poured from some container. On the Gold Coast, larvae have frequently been observed in residual pools formed in earth drains where the grade of the ditch prevented complete removal of all water. G. H. E. Hopkins (1936, "Mosquitoes of the Ethiopian Region" Part I, p. 111, British Museum) considers that the original breeding places of *A. aegypti* were in tree holes. Brigadier G. M. Findlay, R. A. M. C. (personal communication) quotes E. Francis (1907, "Observations on the Life Cycle of *Stegomyia calopus*," Public Health Rep. USPH & Mar. Hosp. Serv. 22:381), "They [*A. aegypti*] were not found breeding in any [collection of water with] natural bottoms." Findlay further states, "The context shows that he meant puddles in the earth. Carter (1931, *Yellow Fever: An Epidemiological and Historical Study of Its Place of Origin*, The Williams Wilkins Co.) is quite sure that this observation is correct. He quotes an unpublished report by Dr. Henry Hanson on the basis of his experience in Peru, 'We have found them breeding in no collection of water with exclusively earth (i. e. mud) sides at the surface of the water.' Carter corroborates this for Havana, United States, Panama, Guayaquil and Peru."

Findlay also states that in West Africa British workers have seen *A. aegypti* breeding on mud tops of African houses and in footprints of children around the Lagoon at Saltpond, Gold Coast. Major P. F. Mattingly, R. A. M. C., has found *A. aegypti* breeding in grass-bottomed and grass-sided drains at Takoradi and Accra, Gold Coast.

From the observations of the writer, in West Africa, at least, it is necessary not only to examine water resulting from the carelessness of man, but also to keep a close check on natural situations as well, if *Aedes aegypti* and yellow fever are to be eradicated.

#### FICHER ENTOMOLOGIQUE CHINOIS (Album of Chinese Insects).—

This remarkable serial, published by the Musée Heude, Shanghai, from 1939 to 1941, consists entirely of excellent color plates in separate folders, each accompanied by a reproduction of the original description of the insect. There are ten or more plates per series, and five series have appeared. The total of 59 plates treat 48 species: some with two views, or two sexes, illustrated. The first three series are colored by hand, and the last two are lithographed. The prices, U. S. \$25.00 each for the first three series and U. S. \$15.00 each for series 4 and 5, are high, but this fine type of entomological art is now almost extinct. Most of the species illustrated are from types of Chinese insects in the Musée Heude, and many of them were described in the *Notes d'Entomologie Chinoise*.—J. L. GRESSITT.

## STUDIES OF PISTOL CASE-BEARER PARASITES<sup>1</sup>

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The pistol case-bearer, *Coleophora malivorella* Riley (LEPIDOPTERA, COLEOPHORIDAE), is a native American insect which was described by Riley (1878). Gould (1931) recorded its range as extending from Virginia to Kansas and northward to Canada. Thorough reports on its life history have been given by Gould (1931 and 1936) and by Steiner and Worthley (1941).

In most areas, the pistol case-bearer has been considered as a curiosity rather than as a pest. Serious outbreaks on the foliage and fruit of apple have occurred infrequently, however, in several sections of eastern and central United States and in Canada.

Although biological control has been regarded as a dominant factor in reducing the pistol case-bearer to a status of minor importance as an apple pest, the literature contains only passing reference to the parasites of this insect. Riley (1878) first indicated the importance of parasitism in controlling *C. malivorella* by stating that the amount of parasitism by a minute Chalcid fly "increased to such an extent that it bids fair to render additional remedies against the coleophora unnecessary." Lintner (1882) noted that pistol case-bearer injury in an Erie County, Pennsylvania, apple orchard was no longer serious due to the beneficial results of an attack which had been made on the host by a Chalcid parasite during 1880-1881. Lowe (1897) found three unidentified parasite species attacking this host in New York. During the decade 1929-1939, Gould and Geissler (1940) compiled a comprehensive list of parasites reared from *C. malivorella* in Virginia and West Virginia.

In conjunction with investigations conducted by Steiner and Worthley (1941) on the life history and control of the pistol case-bearer at Arendtsville, Pennsylvania, these studies were undertaken during 1940 and 1941 to determine the importance of the natural enemies of this insect.

### EGG PARASITES

Leaves containing 1,500 host eggs were collected at random from various orchards within the infested region near Arendtsville, Pennsylvania, on July 16, 1940, several days after the peak of egg deposition had occurred. A small paper punch was used to separate the egg from the surrounding leaf tissue, after which the eggs were placed in glass vials, and observed daily for emerging parasites. Care was taken to remove

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Studies in Pennsylvania were conducted under the direction of H. M. Steiner and, in Delaware, at the request of L. A. Stearns. Acknowledgment is made to E. Gould for the parasite specimens used in identification work.

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as much of the leaf tissue around the egg as possible, in order to eliminate parasites, other than those of the egg itself, which might have been present within the leaf tissue.

No parasites were reared from these eggs. Gould and Geissler (1940), however, list *Anagrus epos* Gir., *Trichogramma minuta* Riley, and *Zagrammosoma* sp. as recovered from pistol case-bearer eggs in Virginia and West Virginia.

#### PARASITES OF FIRST- AND SECOND-INSTAR LARVAE

A collection of 1,000 first-instar host larvae was made from several orchards near Arendtsville, Pennsylvania, on July 30, 1940. No parasites were reared from this material. Furthermore, the literature does not mention previous recovery of parasites at this stage of larval growth in the pistol case-bearer, although Doner (1936) records a species of *Derosternus* as an ectoparasite in the mines of young cherry case-bearer larvae, *Coleophora pruniella* Cl.

A similar collection of 1,000 host larvae on August 25, 1940, did not yield any parasites.

#### PARASITES OF THIRD-INSTAR LARVAE

Pistol case-bearer hibernating (third-instar) larvae were found to be highly susceptible to attack by several parasites. Collections<sup>3</sup> of

TABLE I  
PARASITISM OF HIBERNATING (THIRD-INSTAR) PISTOL CASE-BEARER LARVAE

	Pennsyl- vania	Delaware*	Virginia	Illinois
Host Larvae (Number)	577	869	3,345	526
Parasitism (Per Cent)	4.5	22.2	9.7	1.9
Host Survival (Per Cent)	83.4	64.1	84.0	72.1
Parasite Survival (Per Cent)	55.3	85.5	91.4	0 9

\*Delaware larvae collected in April, 1941; other samples, in April, 1940.

overwintered larvae made at Arendtsville, Pennsylvania, Winchester, Virginia, and Kinmundy, Illinois, during the first week of April, 1940, showed a parasitism of 4.5, 9.7, and 1.9 per cent, respectively (Table I).

Collections of overwintered larvae made at Camden, Delaware, during April, 1941, showed a parasitism of 22.2 per cent. The low parasitism of the Illinois larvae may have been due to the fact that they were collected from one tree, instead of a representative collection from several orchards as in other localities. A wide variation may be noted between the survival of overwintered hosts and parasites.

Parasitization of the overwintering host larvae occurred generally throughout September and October, the majority of them being fixed

<sup>3</sup>Acknowledgment is made to H. M. Steiner, W. S. Hough, and S. C. Chandler for these collections.



in hibernating positions on the twigs. Some, however, were parasitized while still feeding upon the foliage at this time, and never assumed hibernating positions. A paralysis induced by the parasite stings caused larval activity to cease, and the host remained attached to the leaf, thereby dropping to the ground at leaf-fall. Observations on the establishment of the host larvae for hibernation showed a loss of 11.6 per cent upon completion of leaf-fall. It is not known whether this loss is entirely attributable to parasite attack.

The parasites recovered from the several collections listed in Table I are as follows: *Eurydinota lividicorpus* Gir. (94.1 per cent), *Habrocytus phycidis* Ashm. (4.2 per cent), and *Eupelmus cyaniceps* var. *amicus* Gir. (1.7 per cent). The parasites overwintered within the host cocoons as pupae and, with the rise of temperature in the latter part of April, began to emerge from the cases. The peak of emergence occurred during the first and second weeks of May.

#### PARASITES OF FOURTH- AND FIFTH-INSTAR LARVAE

Collections of host cases were made from eight apple orchards distributed throughout an area of pistol case-bearer infestation involving

TABLE II  
EMERGENCE OF PISTOL CASE-BEARER PARASITES, ARENDTSTVILLE,  
PENNSYLVANIA, JUNE-JULY, 1940

Orchard	Cases Examined	Parasitized Hosts	Parasite Emergence	PER CENT	
				Parasitism	Host Emergence
Baltzley.....	407	39	54	9.6	58.2
Barber.....	317	33	63	10.4	80.4
Blue Ribbon....	1265	78	113	6.2	57.3
Boyer.....	300	22	45	7.3	71.0
Keller.....	300	72	120	24.0	60.3
Kunkle.....	282	26	50	9.2	36.5
Roth.....	304	19	21	6.2	83.9
Taylor.....	300	35	98	11.7	61.0
Totals and Averages...	3475	324	564	9.3	62.2

18 square miles near Arendtsville, Pennsylvania, during June 15-20, 1940. Parasite emergence from this material commenced on June 18, and continued until July 29. There were two peaks of emergence, one occurring on June 25, and another on July 15-17. Parasitism varied from 6 to 24 per cent among the eight orchards. An average parasitism of 9.3 per cent was recorded from the 3475 cases under observation (Table II).

Fifteen species of parasites were recovered from this material as follows:<sup>4</sup> *Acrolyta aletiae* Ashm., *Anachaelopsis tortricis* (Coq.), *Aphe-*

<sup>4</sup>Identified by C. F. W. Muesebeck, A. B. Gahan, D. G. Hall, and R. A. Cushman, U. S. Bureau of Entomology and Plant Quarantine.

*linus mali* (Hald.), *Dibrachys cavus* (Walk.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurytoma tylodermatis* Ashm., *Eurydinota lividicorpus* Gir., *Epiurus indagator* (Cress.), *Habrocytus phycidis* Ashm., *Hemiteles tenellus* (Say), *Microbracon gelechiae* (Ashm.), *Microbracon pygmaeus* (Prov.), *Spilochalcis albifrons* (Walsh), *Sympiesis* sp., and *Tetrastichus* sp.

All parasites attacked the mature pistol case-bearer larva, with the exception of *Anachaetopsis tortricis* (Coq.), which was reared from the host pupa. *Dibrachys cavus* (Walk.) and *Hemiteles tenellus* (Say) were recovered as secondary parasites of *Eurydinota lividicorpus* Gir. and *Habrocytus phycidis* Ashm. One female *Aphelinus mali* (Hald.) was reared from the host as an accidental parasite.

Collections of host cases were made in two apple orchards at Camden, Delaware, during June, 1941. The pistol case-bearer infestation

TABLE III  
EMERGENCE OF PISTOL CASE-BEARER PARASITES,  
CAMDEN, DELAWARE, JUNE-JULY, 1941

Orchard	Cases Examined	Parasitized Hosts	Parasite Emergence	PER CENT	
				Parasitism	Host Emergence
Lord Bros.....	200	19	41	9.5	80.0
Thomas.....	630	203	305	32.2	61.6
Totals and Averages...	830	222	346	26.8	66.0

was restricted to a small area in this vicinity. The population in both orchards was very light, although extensive defoliation had occurred several years previously.

Parasite emergence from this material commenced on June 3 and continued until July 11. Peak emergence occurred between June 14 and 20. Average parasitism for the two orchards amounted to 26.8 per cent (Table III). Five species of parasites were reared from the 830 host cocoons under observation, namely, *Epiurus indagator* (Cress.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurydinota lividicorpus* Gir., *Habrocytus phycidis* Ashm., and *Hemiteles tenellus* (Say).

#### EFFECT OF TEMPERATURE UPON EMERGENCE OF HOST AND PARASITES

Eight daily observations were made in order to determine the optimum temperature for emergence of the host and its parasites at Arendtsville, Pennsylvania, during June and July, 1940. The host cocoons were kept in an open screened insectary to approximate field conditions.

According to the results summarized in Table IV, 74.8 per cent of the adult case-bearers and 57.0 per cent of the parasites emerged during a temperature range of 71–80° F. As the optimum temperature usually

existed between 9:00 A. M. and 3:00 P. M., maximum emergence of both host and parasites occurred during this period of time.

TABLE IV

INFLUENCE OF TEMPERATURE UPON EMERGENCE OF THE PISTOL CASE-BEARER AND ITS PARASITES, ARENDTSVILLE, PENNSYLVANIA, 1940

Date	TEMPERATURE RANGE							
	51-60° F.		61-70° F.		71-80° F.		81-90° F.	
	Host	Parasites	Host	Parasites	Host	Parasites	Host	Parasites
June 27.....					4	12	15	8
28.....					22	13		
29.....			34	7	32	29		
30.....	15		4	6	40	1		
July 1.....			11	5	52	3		
2.....					121	6		
3.....		4	23	17				
4.....	8		3	3	211	8		
5.....		1	19	9	212	7		
6.....			9		231	6		
7.....	2	1	2	3	165	8	43	
8.....			5		113	9	104	12
9.....			2	2	99	7	116	
10.....				1	126	6	30	2
11.....					54	7	55	11
Totals.....	25	6	112	53	1482	122	363	83
Average Per Cents	1.3	2.8	5.7	24.8	74.8	57.0	18.2	15.4

## LONGEVITY OF PARASITES

Immediately upon emerging from the cocoons, the parasites were placed in shell glass vials loosely stoppered with cotton. Food was supplied in the form of a raisin mounted on a pin which was inserted in the stopper. All insects were kept in shaded situations to prevent undue activity. Daily observations were recorded on the longevity of the principal case-bearer parasites (Table V).

The female *Eurydinota lividicorpus* Gir., the most important primary parasite, having a maximum length of life at 65 days, showed a mean longevity of 25.5 days when supplied with food, against a life span of but 6.6 days without food. *Microbracon pygmaeus* (Prov.) showed a mean longevity of 22.1 days with food, as against only 7.4 days without food. Other species of parasites were not tested in detail, due to the limited numbers available.

## RELATIVE ABUNDANCE OF PARASITES

The parasites reared from mature pistol case-bearer larvae and pupae at Arendtsville, Pennsylvania, ranked in the following order of importance (Table VI): *Eurydinota lividicorpus* Gir. (59.9 per cent), *Habrocytus phycidis* Ashm. (8.9 per cent), *Microbracon pygmaeus* (Prov.)

TABLE V  
LONGEVITY OF PISTOL CASE-BEARER PARASITES

Species	Number of Individuals		Maximum Length of Life in Days		Minimum Length of Life in Days		Mean Length of Life in Days	
	Male	Female	Male	Female	Male	Female	Male	Female
<i>Microbracon pygmaeus</i> (Prov.) (A)	25	18	5	9	3	3	4.4	7.4
(B)	13	29	18	58	3	4	12.0	22.1
<i>Eurydinota lividicorpus</i> Gir. (A)	56	137	9	9	2	3	5.2	6.6
(B)	74	190	24	65	3	4	11.3	25.5
<i>Epiurus indagator</i> (Cress.) (A)	10	10	5	6	2	3	3.3	4.5
(B)	19	12	9	12	4	4	5.4	8.1
<i>Habrocytus phycidis</i> Ashm. (A)	10	10	6	7	4	3	4.2	5.7
(B)	10	20	20	34	7	11	12.9	19.3
<i>Anachaelopsis tortricis</i> (Coq.) (A)	1	5	3	7	.....	3	3.0	4.4
(B)	1	21	4	7	.....	2	4.0	4.0
<i>Eupelmus cyaniceps</i> var. <i>amicus</i> Gir. (A)	12	23	8	17	2	3	5.1	10.4
(B)	10	25	13	31	4	5	8.4	16.5
<i>Spilochalcis albifrons</i> (Walsh) (A)	0	1	.....	3	.....	.....	.....	3.0
(B)	1	5	6	10	.....	6	6.0	8.0

(A)—without food; (B)—with food.

TABLE VI  
RELATIVE ABUNDANCE OF PISTOL CASE-BEARER PARASITES\*

SPECIES	PENNSYLVANIA Per Cent			DELAWARE Per Cent		
	Total	Males	Females	Total	Males	Females
<i>Eurydinota lividicorpus</i> Gir..	59.9	26.3	73.7	80.3	25.5	74.5
<i>Habrocytus phycidis</i> Ashm...	8.9	40.0	60.0	12.0	31.0	69.0
<i>Epiurus indagator</i> (Cress.)..	5.3	73.3	26.7	4.6	12.5	87.5
<i>Microbracon pygmaeus</i> (Prov.).....	7.4	38.1	61.9	.....	.....	.....
<i>Hemiteles tenellus</i> (Say).....	3.9	27.3	72.7	2.6	22.2	77.8
<i>Eupelmus cyaniceps</i> var. <i>amicus</i> Gir.....	4.2	25.0	75.0	0.5	50.0	50.0
<i>Anachaelopsis tortricis</i> (Coq.).....	4.4	12.0	88.0	.....	.....	.....
Misc. spp.....	6.0	33.3	66.7	.....	.....	.....
Totals and Averages....	100.0	30.7	69.3	100.0	25.6	74.4

\* Based on 3475 host cases in Pennsylvania and 830 host cases in Delaware.

(7.4 per cent), *Epiurus indagator* (Cress.) (5.3 per cent), *Anachaetopsis torricis* (Coq.) (4.4 per cent), *Eupelmus cyaniceps* var. *amicus* Gir. (4.2 per cent), and *Hemiteles tenellus* (Say) (3.9 per cent).

The emergence of *Eurydinota lividicorpus* Gir. occurred uniformly throughout the period in which the case-bearers were under observation. In contrast, *Microbracon pygmaeus* (Prov.) emerged in abundant numbers during the period June 18-30; *Habrocytus phycidis* Ashm., from July 1 to 12; and *Eupelmus cyaniceps* var. *amicus* Gir. in the latter portion of the emergence period, namely, July 13-29.

At Camden, Delaware, the emergence of parasites approximated that of the same species in Pennsylvania. *Eurydinota lividicorpus* Gir. comprised 80.3 per cent of the total number of parasites reared, followed by *Habrocytus phycidis* Ashm. (12.0 per cent), *Epiurus indagator* (Cress.) (4.6 per cent), *Hemiteles tenellus* (Say) (2.6 per cent) and *Eupelmus cyaniceps* var. *amicus* Gir. (0.5 per cent).

Sex ratios of the parasites reared from the above-named localities are given in Table VI.

#### CUMULATIVE EFFECT OF PARASITISM

Since the pistol case-bearer has but one generation per year and all stages are exposed to parasite attack due to their more or less stationary positions and protective cases, it is apparent that the cumulative effect of parasitism must be considered in order to obtain an accurate indication of the importance of parasites in reducing the host population.

The parasitism of mature case-bearer larvae and pupae (9.3 per cent, Table II), and of overwintering larvae (4.5 per cent, Table I) observed in the Arendtsville collections, induces the assumption that a total cumulative parasitism of 13.8 per cent existed for the pistol case-bearer during 1940, not including the possible parasitization of host eggs and of the earlier larval-instar from which no recoveries were made and, also, the parasitized host larvae which fell from their feeding positions on the trees. Likewise, a total cumulative parasitism of 49.0 per cent (Tables I and III) existed for overwintering and mature pistol case-bearer larvae in Delaware during 1941.

The value of predators in reducing populations was not determined. However, Steiner and Worthley (1941) observed two mirids, *Diaphnidia pellucida* Uhler and *Hyaliodes vitripennis* Say, feeding on pistol case-bearer larvae at several periods during the year.

*Hemiteles tenellus* (Say) was found to be a secondary parasite of *Eurydinota lividicorpus* Gir. and *Habrocytus phycidis* Ashm. *Dibrachys cavus* (Walk.) was reared from *E. lividicorpus* Gir. Both hyperparasites also attacked the mature case-bearer larvae. Although few hyperparasites were recovered from the collections of host cocoons, it is probable that these species and others may play an important role in reducing primary parasite populations, thus permitting serious pistol case-bearer outbreaks on apple.

#### ALTERNATE HOSTS OF PARASITES

Since adults of the principal pistol case-bearer parasite, *Eurydinota lividicorpus* Gir., upon emergence from the host cocoons in June and

July, were not detected as being parasitic upon the young host larvae until September, it seems probable that an alternate host or hosts are present to enable the parasite to tide over the period until the newly-developing case-bearer larvae become large enough to permit the parasite to obtain sufficient sustenance.

The unspotted tentiform leaf-miner, *Parornix prunivorella* Cham., which occurred in large numbers on the foliage in every orchard from which case-bearer collections were made, was investigated as a possible alternate host of the parasites. One thousand larval "tents" were enclosed in glass vials, and were observed daily for emerging parasites. Two pistol case-bearer parasites, *Sympiesis* sp. and *Tetrastichus* sp., were recovered in sufficient numbers to establish a parasitism of 16.2 per cent. Efforts to rear *E. lividicarpus* Gir. on this host proved fruitless, although females were observed attempting to deposit eggs within the larval "tents."

Empty cylindrical cases of an unknown species of case-bearer (possibly cigar case-bearer) were found attached to the trunks of peach and sour-cherry trees in the vicinity of a pistol case-bearer infested orchard. It is assumed that this species had made its way to the trunks of these trees from the surrounding vegetation on which it had matured, since no cases were observed on the twigs and foliage. However, examination of the surrounding vegetation during August and September, 1940, did not reveal the presence of this insect. Parasite emergence holes were found in the cases of this species, and their similarity to those formed by *E. lividicarpus* Gir., et al., leads to the assumption that parasitism is probably effected by the same parasite species that attack the pistol case-bearer. Parallel life cycles of these two species of *Coleophora*, on the other hand, reduces the possibility that the unknown case-bearer serves as an alternate host. Further research is necessary to clarify this aspect of biological control. It is possible that the lack of alternate or secondary hosts is a limiting factor in the size of the parasite population, with a resultant increase in host numbers.

#### EFFECT OF SPRAYING UPON PARASITE ABUNDANCE

Prior investigations do not provide information concerning the effect of artificial control measures upon the parasite populations of *Coleophora* species. Since periodic collections of host larvae were not made throughout an entire season in a specific locality, data cannot be presented which would give a complete analysis of spraying effects within a given orchard.

All orchards, from which host collections were made at Arendtsville, Pennsylvania, received the recommended schedule of lead arsenate sprays for codling moth control. Therefore, comparisons between sprayed and unsprayed plots are impossible. Collections of overwintered pistol case-bearer larvae were made from unsprayed and sprayed orchards at Camden, Delaware, on April 10, 1941. Examination of these samples showed a parasitism of 14.8 per cent for the sprayed orchards, as opposed to 26.5 per cent for the unsprayed orchard. Similar collections of mature host larvae on June 3 showed a parasitism of 9.5 per cent for the sprayed orchard, while that of the unsprayed orchard reached 32.2 per cent.

## SURVEY OF PISTOL CASE-BEARER PARASITES

A review of pistol case-bearer parasites, as recorded by various workers, is given in Table VII. The classification used is similar to that employed in Cornell University Agricultural Experiment Station Memoir 101, "A List of the Insects of New York," 1926.

TABLE VII  
PARASITES OF THE PISTOL CASE-BEARER

SPECIES	LOCALITY					RECORDED BY§
	West Virginia	Virginia	Pennsylvania	Delaware	Illinois	
HYMENOPTERA						
CHALCIDOIDEA						
APHELINIDAE						
<i>Aphelinus mali</i> (Hald.).....			x			Beacher
CALLIMOMIDAE						
<i>Monodontomerus</i> ? n. sp.....	x					Gould
CHALCIDIDAE						
<i>Hockeria</i> sp. (probably new).....	x					Gould
<i>Microdontomerus anthonomi</i> Cwfd.....		x				Gould
<i>Spilochalcis albifrons</i> (Walsh).....	x		x			Gould, Steiner
<i>Spilochalcis torvina</i> (Cress.).....	x					Gould
ELASMIDAE						
<i>Elasmus setosiscutellatus</i> Cwfd.....	x					Gould
ENTEDONTIDAE						
<i>Horismenus microgaster</i> (Ashm.).....	x					Gould
EULOPHIDAE						
<i>Cirrospilus flavicinctus</i> Riley.....	x					Gould
<i>Eulophus magnisulcatus</i> Gir.....	x					Gould
* <i>Sympiesis</i> n. sp.....	x		x			Gould, Steiner
<i>Sympiesis argenticoxa</i> Gir.....	x					Gould
<i>Tetrastichus</i> sp.....	x		x			Gould, Steiner
† <i>Zagrammosoma</i> sp.....		x				Gould
EUFELMIDAE						
* <i>Eupelmus allyni</i> (French).....	x					Gould
* <i>Eupelmus cyaniceps</i> var. <i>amicus</i> Gir.....	x	x	x	x	x	Gould, Steiner, Beacher
EURYTOMIDAE						
<i>Eurytoma tylodermatis</i> Ashm.....			x			Steiner
<i>Eurytoma</i> sp. (very close to <i>Phoebus</i> Gir.)	x					Gould
MYMARIDAE						
† <i>Anagrus epos</i> Gir.....		x				Gould
PTEROMALIDAE						
<i>Catolaccus aeneoviridis</i> Gir.....	x					Gould
<i>Coleopisthia</i> ( <i>Trineptis</i> ) <i>hemerocampae</i> Gir.....	x					Gould
† <i>Dibrachys cavius</i> (Walk.).....			x			Steiner
* <i>Eurydinota lividicorpus</i> Gir.....	x	x	x	x	x	Gould, Steiner, Beacher
<i>Habrocytus</i> sp. Nov. (possibly <i>phycidis</i> )..	x					Gould
<i>Habrocytus ihyridopterigis</i> Howard.....	x					Gould
* <i>Habrocytus piercei</i> Cwfd.....	x					Gould

TABLE VII—(Continued)

SPECIES	LOCALITY					RECORDED BY§
	West Virginia	Virginia	Pennsylvania	Delaware	Illinois	
* <i>Habrocytus phycidis</i> Ashm.....	x	...	x	x	...	Gould, Steiner, Beacher
<i>Hypopteromalus inimicus</i> Mues.....	x	...	...	...	...	Gould
* <i>Hypopteromalus tabaccum</i> Fitch.....	x	...	...	...	...	Gould
TRICHOGRAMMIDAE						
† <i>Trichogramma minuta</i> Riley.....	x	...	...	...	...	Gould
ICHNEUMONOIDEA						
BRACONIDAE						
<i>Bassus coleophorae</i> Rohw.....	x	...	...	...	...	Gould
<i>Bassus</i> n. sp.....	x	...	...	...	...	Gould
<i>Doryctinae</i> : n. g. and n. sp. (may be a new species of <i>Rhoprocentrus</i> ).....	x	...	...	...	...	Gould
<i>Macrocentrus instabilis</i> Mues.....	x	...	...	...	...	Gould
<i>Macrocentrus</i> n. sp.....	x	...	...	...	...	Gould
<i>Meteorus vulgaris</i> Cress.....	x	...	...	...	...	Gould
* <i>Microbracon geleckiae</i> (Ashm.).....	x	...	x	...	...	Gould, Steiner
* <i>Microbracon pygmaeus</i> (Prov.).....	x	...	x	...	...	Gould, Steiner
<i>Opius</i> sp.....	x	...	...	...	...	Gould
<i>Rhoprocentrus</i> sp.....	x	...	...	...	...	Gould
ICHNEUMONIDAE						
<i>Acrolyta aletiae</i> Ashm.....	...	...	x	...	...	Steiner
<i>Angitia</i> sp.....	x	...	...	...	...	Gould
<i>Hemiteles gracilariæ</i> Ashm.....	x	...	...	...	...	Gould
† <i>Hemiteles tenellus</i> (Say).....	x	...	x	x	...	Gould, Beacher
* <i>Epiurus indagator</i> (Cress.).....	x	...	x	x	...	Gould, Steiner, Beacher
<i>Epiurus</i> sp. (probably <i>indagator</i> (Cress.))	x	...	...	...	...	Gould
<i>Hyposoter annulipes</i> (Cress.).....	x	...	...	...	...	Gould
<i>Itoplectis conquisitor</i> Say.....	...	x	...	...	...	Gould
VESPOIDEA						
BETHYLIDAE						
<i>Goniozus hortorum</i> Brues.....	x	...	...	...	...	Gould
DIPTERA						
TACHINIDAE						
<i>Anachastopsis tortricis</i> (Coq.).....	x	...	x	...	...	Gould, Steiner
SCATOPSIDAE						
<i>Rhegmoclema atrata</i> (Say).....	x	...	...	...	...	Gould
<i>Swammerdamella brevicornis</i> Meig.....	...	x	...	...	...	Gould

\* More abundant species.

† Egg parasites.

‡ Secondary parasites.

§ Gould records for 1940; Steiner records for 1941.



## BIOLOGY OF EURYDINOTA LIVIDICORPUS GIR.

Observations were recorded on the life history of *E. lividicarpus* Gir. the most important primary parasite of the pistol case-bearer.

## DESCRIPTION OF SPECIES

Girault (1917) described this species as follows:

"Female: Length 1.65 mm. Dark metallic blue, the wings hyaline, the base and apex of the tibiae and tarsi white. Clypeus striate, gently concave at apex. Head and thorax punctate. Propodeum with distinct, curved lateral carina and no other, the carina forming the lateral rim of the large neck; no spiracular sulcus, the spiracle elliptical, cephalad. Petiole a little longer than wide. Parapsidal furrows half complete from cephalad. Abdomen depressed, delicately scaly distad, segment 2 occupying a fourth of the surface, its caudal margin convex, entire. Antennae inserted somewhat above the ends of the eyes, the scape slender, reaching to the top of the vertex; pedicel twice longer than wide at apex, much longer than any funicle joint; ring-joints unequal; funicle 1 (a ring joint?) quadrate, narrower than the following joints; 2 and 3 subquadrate, wider than 1; 6 twice wider than long. Stigmal vein long and slender, slightly shorter than the marginal which is slightly shorter than the post-marginal.

"The male is similar but funicle 1 is wider than long, still more like a ring-joint, the pedicel shorter; also the cephalic tibiae are reddish-yellow."

## COPULATION AND OVIPOSITION

Adult parasites were kept in glass vials ( $2\frac{1}{4}$  inches in length), and a raisin, mounted on a pin inserted in the stopper of the vial, served as a supply of food and moisture. The adults were observed also to feed at the puncture holes of the host following oviposition. Longevity of the males and females has been discussed previously (Table V).

Copulation took place shortly after emergence. The males pursued the females as soon as they appeared but, upon mounting, were often dislodged by them before successful copulation could be effected. Copulation usually extended for 25 minutes, and several cases were noted in which it lasted 45 minutes or more.

In general, a female required about one week to develop an interest in the host. Case-bearer larvae, introduced into the glass vials, were untouched by newly-emerged parasites, which were more intent upon copulation and feeding. Finally, the oviposition response manifested itself, and the introduction of the host larvae caused an immediate action on the part of the female. Walking carefully over the entire surface of the case, she touched every portion with her antennae, which vibrated rapidly and were held in a widely divergent forward position.

After these preliminary movements, the abdomen was curved downward, and the tip applied to the point of the case where the ovipositor was to be inserted. The point of insertion was usually in the center of the case, the head of the female being directed toward the distal end of the case. In this manner, the thoracic region of the larva was pierced, causing the paralyzing agent to quickly reach a vital part.

Noticeable effort was exerted in piercing the case and, frequently, the female selected several points before the ovipositor could be inserted. During each thrust of the ovipositor, the wings were held flatly over the abdomen. A variable number of stings were required before the host was killed. Small case-bearer larvae ceased movement after but a few thrusts, while mature larvae required as many as 15 or more thrusts before the paralyzing agent became effective. Between thrusts, the females either remained perfectly quiet on the case or, more often, repeated their searching movements over the surface of the case as described previously. Additional thrusts were not necessarily made through the original puncture of the first thrust; other points were frequently chosen.

After being stung, the case-bearer larvae would first retire into the case, but would soon crawl about in an excited manner, in an attempt to dislodge the parasite. Mature larvae frequently succeeded in dislodging the parasite by jerky motions, but the female would immediately return to the case, and inject the ovipositor for several additional thrusts. On occasions when the larvae attempted to crawl about, the female would pinch the thoracic region with its mandibles, causing them to retire into the cases.

When the host larvae finally remained quiet for a few minutes, the true egg thrust occurred, and the ovipositor remained inserted in the case for over a minute. *E. lividicarpus* is an ectoparasite, and the eggs are deposited upon the surface of the larvae. Under laboratory conditions, from one to eight eggs were deposited on an individual, if only a limited number of hosts were present. In the field, 17 larvae were observed on a single host.

The duration of the oviposition period was usually 10 days, with maximum deposition occurring within six days after the beginning of egg laying. The maximum number of eggs deposited by one female was 35, over a period of 10 days (seven eggs on one day), and the average number of eggs deposited per female was 21. One female was observed ovipositing on the 27th day, and another was observed attempting to paralyze a case-bearer on the 44th day, but oviposition did not occur.

#### DEVELOPMENT OF LARVA AND PUPA

In life history studies with *E. lividicarpus* Gir., it was necessary to remove the parasitized larvae from their cases, using insect pins mounted in match sticks as instruments for opening the cases. A camel-hair brush was utilized in transferring the naked larvae to glass slides. Individual parasite larvae attached to the host were placed in the deep cells of "hanging-drop" slides and were sealed with a cover slip, held in place by a drop of water, similar to the method used by Doner (1936).

These were kept in a desiccator, in which a relative humidity of 77 per cent was maintained by a saturated solution of potassium bromide. This procedure enabled the parasite larvae to develop rapidly, and prevented desiccation of the host larvae. It was found to be highly important to keep the desiccator in darkness when not being observed, since light caused the parasite larvae to leave the host and to wander around the glass slide.

Extreme care was necessary in removing the host larvae from the case, immediately after parasitization, since the parasite eggs are easily injured by brushing against the wall of the case. In every instance, where a parasite larva was dislodged from the host after it had commenced feeding, attempts to rear the larva proved futile, even though the parasite was placed directly on the host at the same spot on which it had been feeding previous to removal.

Larval maturity was attained in approximately 11 days after eclosion and, by that time, the larval host was reduced to a flattened, dried mass, with the parasite larvae completely filling the case. Frequently, the entire host was devoured, with the exception of the chitinated portions of the body. In one instance, 10 parasite larvae reached full growth on a single host and later emerged as adults.

When mature (2 mm. in length and 0.5 mm. in width), the parasite larva rested for a short period and then constructed a fine, white cocoon within the case, completing it within 18 to 24 hours. An increase in the size of the thoracic region and a constriction appearing between the thorax and abdomen was indicative of the pre-pupal stage. The pupal stage usually lasted seven days, although this period varied from seven to ten days.

The rate of development of larvae in a single case-bearer cocoon was found to vary, some pupating two to four days in advance of the others.

The complete life cycle averaged 20 days, as follows: egg stage, 36 to 48 hours; larval stage (three instars), 11 days; and pupal stage, 7 days. The minimum life cycle observed was 18 days and the maximum, 22 days; the length varied according to the duration of the pupal period. There appears to be at least two generations annually.

#### EMERGENCE FROM HOST CASES

After from seven to 10 days as pupae, the adult parasites issue from the pistol case-bearer cocoon by chewing a small, round exit hole through the wall. Invariably, the parasites used one exit hole, as many as 10 emerging from a single host case. This hole is usually located on the side of the posterior third of the case. None of the parasites attempted to emerge via the ventral slit in the curved end of the case, through which the adult host would normally have made its emergence.

The sex ratio of parasites emerging from single cases varied greatly; males outnumbering females and vice versa. Several specific examples are cited as follows: case one (two males, six females), case two (four males, five females), case three (four males, no females), case four (five males, two females).

#### SUPERPARASITISM AND MULTIPARASITISM

A female *E. lividicorpus* supplied with a limited number of hosts was found to deposit as many as 10 eggs on a single host larva. Doner (1936) reported a total of 14 eggs being deposited on an individual host. In several instances, as many as 10 parasites emerged from one host case, the host larva having attained maturity and being large enough to furnish the amount of sustenance necessary to rear the parasites.

*E. lividicorpus* and *Habrocytus phycidis* were noted emerging from a single pistol case-bearer cocoon in June, 1941. Doner (1936) records

specimens of *E. lividicorpus* and *Eupelmella vesicularis* emerging from a single case of *Coleophora pruniella* Cl. The same author also observed *E. lividicorpus* feeding upon a larva of *Microbracon pygmaeus* as a secondary parasite. *Hemiteles tenellus* (Say), as previously reported, was a secondary parasite upon *E. lividicorpus*.

#### OCCURRENCE IN OTHER SPECIES OF COLEOPHORA

Hosts of *E. lividicorpus* Gir., recorded to date, include only members of the genus *Coleophora*. A survey of the literature has revealed the notations of *E. lividicorpus* as a parasite of *Coleophora pruniella* Cl. by Petch and Armstrong (1926) and Doner (1936), and of *Coleophora sacramenta* Hein by Essig (1926).

#### SUMMARY

Fifteen species of parasites were reared from the mature larvae and pupae of the pistol case-bearer, *Coleophora malivorella* Riley, at Arendtsville, Pennsylvania, during June and July, 1940, as follows: *Acrolyta aletiae* Ashm., *Anachaetopsis tortricis* (Coq.), *Aphelinus mali* (Hald.), *Dibrachys cava* (Walk.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurytoma tylodermatis* Ashm., *Eurydinota lividicorpus* Gir., *Epiurus indagator* (Cress.), *Habrocytus phycidis* Ashm., *Hemiteles tenellus* (Say), *Microbracon gelechiae* (Ashm.), *Microbracon pygmaeus* (Prov.), *Spilochalcis albifrons* (Walsh), *Sympiesis* sp. and *Tetrastichus* sp.

Parasitism varied from 6 to 24 per cent for all cases examined in eight apple orchards at Arendtsville.

Five species of parasites, namely, *Epiurus indagator* (Cress.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurydinota lividicorpus* Gir., *Habrocytus phycidis* Ashm., and *Hemiteles tenellus* (Say), were reared from the same host collected in two apple orchards at Camden, Delaware, during June and July, 1941. Parasitism varied from 9 to 32 per cent of the cases examined.

*Eurydinota lividicorpus* Gir. was the most important primary parasite of the mature host larvae, comprising 59.9 per cent of the total number of parasites reared at Arendtsville, and 80.3 per cent of those at Camden.

No parasitism was recorded for the egg or the first, two, larval instars of this host. Collections of overwintering host larvae in Pennsylvania, Delaware, Virginia, and Illinois showed parasitism of 4.5, 22.2, 9.7, and 1.9 per cent, respectively. *E. lividicorpus* Gir. was the most important parasite in all instances and comprised 94.1 per cent of the total recoveries.

The cumulative effect of parasitism in host collections at Arendtsville, during 1940, averaged 13.8 per cent for one generation of the host, excluding possible parasitization of the host egg and earlier larval instars from which no recoveries were made and, also, the amount of parasitized larvae which fell from their feeding positions on the trees. Cumulative parasitism for the overwintering and mature hosts averaged 49.0 per cent at Camden.

The unspotted tentiform leaf-miner, *Parornix prunivorella* Cham., served as an alternate host for the two pistol case-bearer parasites, *Sympiesis* sp. and *Tetrastichus* sp.

Spraying was found to materially affect parasite population. Parasitism amounted to 32.2 per cent in an unsprayed Delaware orchard, as compared with 9.5 per cent in an orchard sprayed in accordance with the recommended program for control of important apple pests.

*Hemiteles tenellus* (Say) was observed as a secondary parasite of *Eurydinota lividicarpus* Gir and *Habrocytus phycidis* Ashm. *Dibrachys cavus* (Walk.) was reared from *Eurydinota lividicarpus* Gir. Both hyperparasites also attacked the mature pistol case-bearer larvae.

A list of pistol case-bearer parasites, as recorded by various workers, is included.

Observations were made on the biology of *Eurydinota lividicarpus* Gir, the principal primary parasite of the pistol case-bearer. The average number of eggs deposited per female was 21. A maximum life span of 65 days was recorded for the female, with a mean longevity of 25.5 days. The number of eggs deposited on a host varied from one to 17. The complete life cycle averaged 20 days as follows: egg stage, two days; larval stage (three instars), 11 days; and the pupal stage, seven days. The minimum life cycle was 18 days, and the maximum was 22 days. The length varied according to the duration of the pupal stage. There appears to be at least two generations annually.

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GENERAL CATALOGUE OF THE HEMIPTERA, FASCICLE IV, FULGO-ROIDEA, PART 8, DICTYOPHARIDAE, by Z. P. METCALF. 246 pages, 1946. Published by Smith College, Northampton, Mass. Price \$3.00.

Previous issues of the Catalogue have been noticed in the Annals from time to time. This part continues the excellent format of earlier numbers, as well as the comprehensive data: extensive bibliography, citations of genotype, and notes on geographic distribution. As a lepidopterist the reviewer envies the hemipterists their opportunity to secure such a useful catalogue at a cost within the means even of a college professor. —A. W. L.

# CHINESE LONGICORN BEETLES OF THE GENUS *LINDA* (Coleoptera: Cerambycidae)<sup>1</sup>

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*Linda* is closely related to the large genus *Oberea*, and differs from it principally in having the prothorax quite short, strongly though bluntly tuberculate laterally, more or less swollen or nodose on the disc, and transversely grooved or constricted near apex and base, and in having the elytra considerably broader than the basal portion of the prothorax. *Linda* is largely Chinese in its constituency, and only a few species occur outside the country, in neighboring areas including Indo-China, Assam and perhaps Burma and the East Indies.

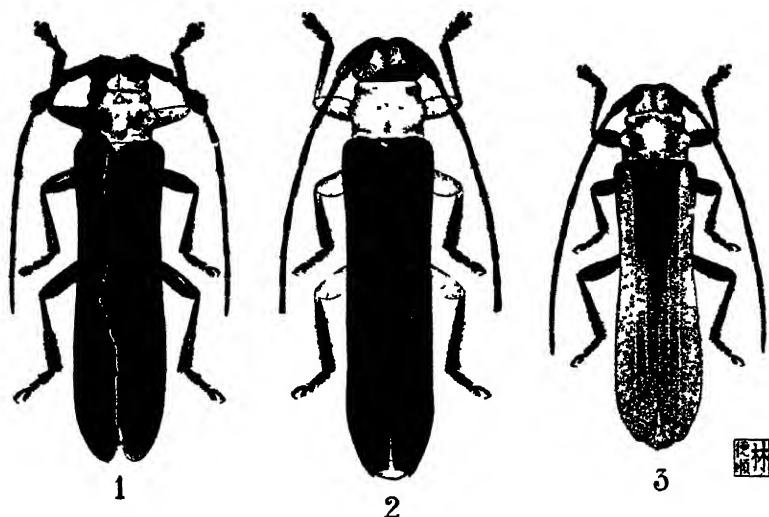


FIG. 1. *Linda fasciculata* Pic; female; W. Hills, near Kunming, Yunnan. ( $\times 2.5$ )

FIG. 2. *Linda major* Gressitt; holotype, female.  $\times (2.5)$

FIG. 3. *Linda nigroscutata* (Fairmaire); female; Kunming, Yunnan.  $\times (2.5)$

*Linda* was erected in 1864 by Thomson for one of two Chinese species which had been earlier described in *Amphionycha* by Chevrolat. In 1902 Fairmaire erected the genus *Miocris* for a single new species, *nigroscutatus*, from Yunnan. This genus was placed by Fairmaire in the tribe Pyrestini of the subfamily Cerambycinae, and compared with *Erythrus* and *Plutonesthes*. In 1907 Pic made a reference to *Miocris*

<sup>1</sup>Contribution from the Lingnan Natural History Survey & Museum, Lingnan University.

*nigroscutatus*, but placed it after *Linda* in a part dealing with a number of Phytoeciini. In the Coleopterorum Catalogus (Aurivillius, 1912 and 1923) and in the Catalogus Insectorum Sinensium (Wu, 1937), *Miocris nigroscutatus* occurs both in the Pyrestini and the Phytoeciini, with identical references in each instance. This peculiar circumstance can be explained by stating that, though *Miocris* was placed by its author in the Pyrestini, it actually has no such relationship, but merely resembles members of that tribe in form, coloration and certain superficial structural characteristics, and actually belongs in the tribe Phytoeciini of the subfamily Lamiinae. What is more, however, I can find no valid characters to justify the retention of *Miocris* as a distinct genus. In 1939 Beeson and Bhatia used the combination *Linda nigroscutata* in a biological paper on the basis of a specimen identification made by a specialist, but without any reference to previous generic placement or indication of new combination.

I am inclined to suspect that the genus *Dasyllinda* Thomson may also prove to be a synonym of *Linda*, since most of the characters ascribed to it for separation from the latter may be found in one or two of Pic's Chinese species of *Linda* which I do not believe should be generically separated from the latter.

### Genus *Linda* Thomson

*Linda* Th., 1864, Syst. Cer. 122, 400 (type: *Amphionycha femorata* Chevrolat); Lacordaire, 1872, Gen. Col. 9: 851, 870; Savio, 1929, Notes d'Ent. Chinoise 1: 3; Matsushita, 1933, Fac. Agr. Hokkaido Imp Univ. 34: 416, 424; Gressitt, 1939, Lingnan Sci. 18: 98, 107; 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

*Miocris* Fairmaire, 1902, Bull. Soc. ent. France, 245 (type: *M. nigroscutatus* Fairm.), new synonym.

Long, slender, somewhat cylindrical; elytra more or less flattened basally, generally broadened preapically, in dead specimens often appearing dehiscent because of warping from dessication; antennae nearly always shorter than body, cylindrical, not very slender, usually black, sometimes ringed with pale; prothorax transverse, bluntly tuberculate laterally, swollen on disc; elytra more often completely black, in some species predominantly pale; head, prothorax and ventral surfaces of body pale, sometimes marked with black.

In most species the pale parts appear yellowish testaceous to reddish ochraceous in dried specimens, whereas in life they are actually bright pinkish red. The extensive pale coloration of *nigroscutata*, however, appears to be of a slightly different nature, being a permanent orange-red, and only slightly paler than in species of *Erythrurus* of the tribe Pyrestini (Cerambycinae).

Nine species of *Linda* were listed from China by Liu in 1934 and Wu in 1937. This paper discusses 15 species, and the total number for the genus now reaches 17. Little is known of the biology of species of *Linda*. In 1929 Savio gave some notes on the habits and larva of *fraterna*, and in 1942 the writer added a small amount of information. Some work has been done on *nigroscutata* in Yunnan (unpublished?) and Assam.

## KEY TO THE CHINESE SPECIES OF LINDA

1. Third antennal segment with a tuft of dark hairs ..... 2  
Third antennal segment lacking a distinct tuft of dark hairs ..... 4
2. Elytra not almost entirely black ..... 3  
Elytra almost entirely black, only very narrowly bordered with pale at extreme apices ..... *fasciculata*
3. Elytra testaceous apically and narrowly margined with testaceous laterally, ..... *apicalis*  
Elytra testaceous, with a black area on basal portion of disc of each, ..... *gibbosicollis*
4. Antennae entirely black, non-annulated ..... 5  
Antennae annulated, at least in part, with pale ..... 9
5. Elytra largely red or testaceous ..... 6  
Elytra entirely black ..... 7
6. Elytra largely red with a black spot or stripe behind scutellum; pronotum with four small black spots ..... *nigroscutata*  
Elytra orange except for pitchy black humeri; pronotum entirely pale; legs and ventral surfaces largely pitchy ..... *tricotata*
7. Elytra subregularly punctured; body more or less stout; antennae relatively thick and shorter than body ..... 8  
Elytra irregularly punctured; body slender; antennae relatively slender and as long as body ..... *gracilicornis*
8. Head and prothorax densely punctured; elytra with round punctures; femora entirely testaceous; length over 20 millimeters ..... *major*  
Head and prothorax sparsely punctured; elytra with square punctures; femora black; length less than 20 millimeters ..... *atricornis*
9. Antennae irregularly ringed with pale; ground color broadly testaceous on bases of fourth to sixth segments, and sometimes with pale hairs on bases of seventh and eighth segments ..... 10  
Antennae regularly ringed with pale hairs on bases of third or fourth and following segments ..... 12
10. Sides of hind thorax partly black, the remainder red ..... 11  
Sides of hind thorax entirely testaceous (or red?) ..... *pratti*
11. Sixth and following antennal segments entirely black; scutellum rounded-truncate apically; elytra broadly and subobliquely truncate apically, ..... *signaticornis*  
Sixth to eighth antennal segments with pale hairs at bases; scutellum broadly emarginate apically; elytra emarginate apically ..... *fraterna*
12. Antennae ringed with pale hairs on bases of fourth and following segments; elytra with more than six rows of punctures ..... 13  
Antennae ringed with pale hairs on bases of third and following segments; vertex largely black; sides of prothorax feebly swollen; elytra with only about six rows of punctures ..... *macilenta*
13. Ventral surfaces of body entirely testaceous; elytra entirely black ..... 14  
Ventral surfaces of body largely black; elytra pale apically and along suture ..... *nigriventris*
14. Elytra with about 12 punctures across middle of each; prothorax moderately swollen laterally; pronotal disc subevenly convex (S. E. China), ..... *femorata*  
Elytra with about 16 punctures across middle of each; prothorax strongly protuberant laterally; pronotal disc with three prominent partly isolated tubercles (Formosa) ..... *annulicornis*

1. *Linda annulicornis* Matsushita

*Linda annulicornis* Mats., 1933, Jl. Fac. Agric. Hokkaido Imp. Univ. 34: 424, fig.<sup>1</sup>

Head, prothorax and ventral surfaces of body pinkish (testaceous in dried specimens); elytra entirely black; antennae ringed with pale on bases of fourth and following segments; elytra with about 12 punctures across middle of each.

Some specimens (California Academy of Sciences) were taken in Formosa in 1932 and 1934 by the writer.

*Distribution*: Formosa<sup>1</sup>.



2. *Linda apicalis* Pic

*Linda apicalis* Pic, 1906, Mat. Long. 6(1): 17<sup>1</sup>; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

Moderately robust and slightly elongate; dull; partly black, partly testaceous; antennae slightly exceeding middle of body, black, third and following segments ringed with gray basally, the third very thick and bearing a weak brush of hairs apically; head testaceous, extensively marked with black on each side of vertex and frons; prothorax short and broad, swollen, testaceous; scutellum testaceous; elytra slightly constricted towards middle, black, a large apical spot, and a narrow lateral margin, testaceous; legs black with anterior femora, the basal portions of middle femora, and the coxae entirely, testaceous. Length 22 mm. (After Pic).

A specimen from Tibet is in the American Museum of Natural History in New York. New to Tibet.

*Distribution*: Yunnan<sup>1</sup>; Tibet.

3. *Linda atricornis* Pic

*Linda atricornis* Pic, 1924, Mel. Exot. Ent. 41: 19<sup>1</sup>; Savio, 1929, Notes d'Ent. Chinoise 1: 3<sup>2</sup>; Gressitt, 1939, Notes d'Ent. Chinoise 6: 126<sup>3</sup>; 1940, *ibid.* 7: 197<sup>4</sup>; 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10<sup>5</sup>; 1942, *ibid.* 8: 41.

Head (except eyes, labrum and mandibles), prothorax, scutellum, ventral surface of body, basal thirds of femora, extreme bases of tibiae, and tarsal claws, reddish testaceous; antennae, elytra, eyes, labrum, mandibles and most of legs black; pale portions clothed with fine silvery pubescence and erect hairs; bases of elytra and undersurfaces of antennae with sparse erect black hairs. Head densely and coarsely rugulose-punctate; vertex shallowly grooved; inferior eye-lobes slightly broader than deep; antennae five-sixths as long as body, scape nearly as long as third segment, following gradually shorter; prothorax one-half again as broad as long, swollen above and behind middle of each side, its surface densely punctured except on each side of middle of disc; scutellum declivitous, truncate, elytra two and one-half times as long as head and prothorax united, slightly narrowed in middle, each impressed with about ten subregular rows of deep, squarish punctures, most of them larger than distances separating them, apices obliquely emarginate-truncate. Length 14-18.5 mm.; breadth 3.5-4.2.

A specimen (American Mus. Nat. Hist.) was collected at Yenping, Fukien Prov., June 12, 1917, probably by the Rev. Harry Caldwell.

*Distribution*: Kiangsu (Shanghai<sup>1</sup>; Kao-ghiao<sup>2</sup>, Lou-bou<sup>2</sup>); Chekiang (Tien-mu Shan<sup>3</sup>); Fukien (Yen-ping<sup>4</sup>); Chahar (Yangkiaping<sup>4</sup>); N.E. Szechuan; Sikang: "Upper Kuanhsien."<sup>5</sup>

4. *Linda fasciculata* Pic

*Linda fasciculata* Pic, 1902, Mat. Long. 4 (1): 32<sup>1</sup>, Fig. 1; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10<sup>2</sup>; 1942, *ibid.* 8: 40.

Moderately long; prothorax and scutellum reddish ochraceous; ventral surfaces of body almost entirely reddish or yellow; head, antennae, elytra and legs largely black. Head black between and behind eyes, remainder yellow; antennae not reaching elytral apices, black, with bases of third to seventh segments ringed with whitish cinereous, the third having a brush of dark hairs apically; prothorax

short, very broad, distinctly tuberculate at sides; elytra a little broader than prothorax, very long, slightly constricted at middle, subangulately rounded at apices, which are narrowly reddish, deeply and rather closely punctured and with traces of feeble costae; legs black except for yellow femora and bases of tibiae of anterior pair and bases of femora and tibiae of middle pair; ventral surfaces of body yellow with sides of breast largely black. Length 17-21 mm.; breadth 3.8-5.

Three specimens (Lingnan Nat. Hist. Mus.) were taken in the Western Hills, alt. 2100 meters, near Kunming, Yunnan Prov., July 7, 1940, by the writer.

*Distribution*: "Szechuan" ("Mongtze"<sup>1</sup>); Yunnan (Western Hills<sup>2</sup>, near Kunming).

### 5. *Linda femorata* (Chevrolat)

*Amphionycha femorata* Chev., 1852, Rev. Zool. (2) 4: 418<sup>1</sup>.

*Linda femorata*, Thomson, 1864, Syst. Ceramb.: 122; Lacordaire, 1872, Gen. Col.

9: 870; Schwarzer, 1925, Ent. Blatter 21: 154<sup>2</sup>; Savio, 1929, Notes d'Ent.

Chinoise 1: 4<sup>3</sup>; Gressitt, 1937, Lingnan Sci. Jl. 16: 620<sup>4</sup>; 1939, ibid. 18: 108<sup>5</sup>;

1939, Notes d'Ent. Chinoise 6: 127<sup>6</sup>; 1940, ibid. 7: 197<sup>7</sup>; 1942, Spec. Publ.

Lingnan N. H. Surv. ; Mus. 7: 10<sup>8</sup>; 1942, ibid 8: 41.

Ventral surfaces, prothorax, scutellum, head and femora largely testaceous; elytra and antennae black, latter clothed with silvery gray pubescence on bases of fourth to last segments; head with a black band across vertex; legs black except for basal two-thirds of middle and hind femora and basal fourth-fifths of anterior pair. Antennae four-fifths as long as body; scape fully as long as third segment; prothorax nearly twice as broad as long, swollen at sides and on disc; elytra deeply and subseriately punctured on basal two-thirds. Length 17-20 mm.; breadth 4.2-5.

Two specimens are in the Lingnan Nat. Hist. Mus. from southwestern China: Shui-tang, alt. 6800-8000 feet, pine mountains 20 miles east of Yunnan-fu (Kunming), Yunnan, Aug. 28, 1934, E. R. Tinkham, and Kweiyang, alt. 1060 meters, Kweichow, July 12, 1940, J. L. Gressitt.

*Distribution*: Kiangsu (Shanghai<sup>1,3</sup>); Chekiang (T'ien-mu Shan<sup>6</sup>); Kiangsi (Hong Shan<sup>4</sup>); Fukien; Kwangtung (Tai-yong<sup>5</sup>); Kwangsi (Ling-yuen<sup>7</sup>); Kweichow (Kweiyang<sup>8</sup>); Yunnan (Shui-tang<sup>8</sup>); Formosa (Kosempo<sup>2</sup>).

### 6. *Linda fraterna* (Chevrolat)

*Anphionycha fraterna* Chev., 1852, Rev. Zool. (2) 4: 419<sup>1</sup>.

*Obera seminigra* Fairmaire, 1887, Ann. Soc. Ent. Belg. 31: 134<sup>2</sup>.

*Linda fraterna*, Gahan, 1894, Trans. Ent. Soc. London: 486; Savio, 1929, Notes

d'Ent. Chinoise 1: 5-8, figs. 1-7<sup>3</sup>; Liu, 1934, Lingnan Sci. Jl. 13: 658<sup>4</sup>; Gressitt,

1937, ibid. 16: 620<sup>5</sup>; 1939, ibid. 18: 108<sup>6</sup>; 1939, Notes d'Ent. Chinoise 6: 127<sup>7</sup>;

1940, Lingnan Sci. Jl. 19: 19<sup>8</sup>; 1942, ibid. 20: 214<sup>9</sup>; 1942, Spec. Publ. Lingnan

N. H. Surv. & Mus. 1: 54, fig. 40<sup>10</sup>; ibid. 8: 41.

*Linda seminigra*, Fairmaire, 1895, Ann. Soc. Ent. Belg. 39: 188.

*Linda seminigra* var. *subtestacea* Pic, 1906, Mat. Long. 6 (1): 17<sup>11</sup>.

*Linda seminigra* var. *luteonotata* Pic, 1907, Mat. Long. 6 (2): 24<sup>12</sup>.

Reddish testaceous; elytra entirely black; occiput partly black; antennae and legs largely black; antennae testaceous on basal half of fourth, and extreme bases of fifth to eighth segments; metaepisternal-

metasternal suture black; legs testaceous on basal portions of femora. Prothorax one-half again as broad as long, strongly swollen above, finely punctured; elytra with deep, subregular punctures and with three feebly raised longitudinal lines. Length 9.5–17 mm.; breadth 1.9–4.5.

One specimen (Lingnan Nat. Hist. Mus.) was taken at Lung-ping-hui, Lien Distr., N. Kwangtung, May 18–20, 1934, by F. K. To. The Musée Heude has specimens from Chusan and Mo-kan Shan in Chekiang, and from Fukien.

*Host plants:* *Prunus japonica* Thunb.<sup>3</sup>, *Cydonia japonica* Pers.<sup>3</sup> (Shanghai); *Rubus* sp.<sup>9,10</sup> (Kwangtung).

*Distribution:* Kiangsu (Shanghai<sup>1,3</sup>, Wou-si<sup>3</sup>, Tchong-kiang<sup>3</sup>, Nan-king<sup>4</sup>, Chekiang<sup>2</sup> (T'ien-mu Shan<sup>7</sup>, Chusan, Mo-kan Shan); Kiangsi (Hong Shan<sup>5</sup>); Fukien; Kwangtung (White Cloud Mt.<sup>8</sup>, near Canton, Taam-yuen-tung<sup>6</sup>, Lung-ping-hui, Yao Shan<sup>6</sup>, Loh-kung<sup>8</sup>, Waichow<sup>9</sup>); Yunnan<sup>11,12</sup>; Formosa.

#### 7. *Linda gibbosicollis* Pic

*Linda gibbosicollis* Pic, 1915, Mel. Exot. Ent. 13: 12<sup>1</sup>; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 41.

Elongate; opaque; black; head partly, and thorax, scutellum and femora more or less, testaceous; elytra testaceous, marked on disc with black, largely testaceous posteriorly; antennae black, third and following segments ringed with gray basally; prothorax short, strongly tuberculate on disc. Length 19 mm. (After Pic).

*Distribution:* Tibet<sup>1</sup>.

#### 8. *Linda gracilicornis* Pic

*Linda gracilicornis* Pic, 1907, Mat. Long. 6 (2): 24<sup>1</sup>; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10<sup>2</sup>; 1942, *ibid.* 8: 41.

Moderately narrow and elongate; testaceous, with mouth-parts, eyes, antennae, elytra, tibiae (except at bases) and tarsi, black; head testaceous, quite deeply grooved along middle; antennae long and slender, nearly reaching elytral apices, entirely black; prothorax testaceous, short, moderately broadened, swollen at sides, narrowed and weakly constricted anteriorly and posteriorly, raised, but not gibbous, on center of disc; scutellum testaceous; elytra black, broader than prothorax, slightly constricted towards middle, obliquely emarginate apically with external angles prominent, discs lacking distinct costae, strongly and irregularly punctured; ventral surfaces of body testaceous, chest marked with black; femora and bases of tibiae testaceous, remainder of legs black. Length 20 mm. (After Pic).

Two specimens (University of Nanking Coll. of Agric. and Lingnan Natural History Museum) were taken at Chengtu, Szechuan in June, 1938, and in upper Kwan-hsien, near the Szechuan-Sikang border, by the University of Nanking. These do not agree completely with Pic's description, and are referred tentatively to this species. They have the ventral surfaces of the body entirely pale, and the femora largely black. The Chengtu specimen measures 17.5 mm. in length and 3.5 in breadth.

*Distribution:* Yunnan<sup>1</sup>; Szechuan<sup>2</sup>.

9. *Linda macilenta* Gressitt, new species

*Male*.—Head, prothorax and ventral surfaces largely pale and elytra black; head reddish, pitchy black on vertex and upper part of frons, except median line, and front of antennal support, as well as side of neck behind upper portion of eye; labrum, mandibles, margins of genae, and distal palpal segments pitchy; antennae black with basal fifth or so of third and following segments ringed with pale hairs; prothorax and scutellum testaceous; ventral surfaces of body reddish testaceous; legs black with coxae and basal two-thirds to four-fifths of femora testaceous; tarsal claws reddish. Head, thorax and abdomen clothed with thin silvery buff pubescence and some flying hairs; elytra with short dull reddish hairs; antennae without any tufts of hairs.

Head as broad as prothorax, convex anteriorly, medially grooved, deeply and somewhat closely punctured. Antennae nearly as long as body, rather slender; scape about as long as third segment; third to tenth gradually decreasing in length, subcylindrical; eleventh about as long as sixth. Prothorax nearly as long as broad, subrectangular, very feebly swollen laterally, moderately and subevenly convex on disc; surface rather sparsely and not very deeply punctured. Scutellum relatively small, slightly broader than long, subtrapeziform. Elytra narrow, obliquely subemarginate-truncate apically; disc of each with six subregular rows of deep squarish punctures at middle, the fifth row from suture uneven and almost a double row, punctures somewhat confused at base and towards apex, much finer near the latter. Ventral surfaces irregularly punctured. Posterior femora not quite reaching to apex of second abdominal segment. Length 14 mm.; breadth 2.55.

*Holotype*, male (No. 58,338 U. S. Nat. Mus.) Mt. Omei, 10,000 ft., Szechuan Province, W. China, July, 1936, D. C. Graham.

Differs from *L. femorata* (Chevr.) in being more narrow with the prothorax less swollen laterally and the antennae ringed with pale hairs from third instead of fourth segment, the ventral surface without any black marking.

10. *Linda major* Gressitt

(Fig. 2)

*Linda major* Gress., 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 3: 8<sup>1</sup>; 1942, *ibid.* 8: 41.

*Female*.—Large; subcylindrical; relatively broad; pronotal disc subevenly swollen. Body orange testaceous to reddish ochraceous in dried specimen (probably pinkish red in life); labrum, eyes, antennae, elytra, tarsi and distal two-thirds of tibiae black; head reddish ochraceous, slightly paler above and darker on clypeus and palpi; mandibles reddish on outer faces, pitchy black below and distally; antennae entirely black, finely clothed with silvery pubescence basally and with closer and thinner dull golden brown pubescence distally, with a few fine subperpendicular hairs below: pale on scape and blackish beyond; prothorax orange testaceous with a slight ochraceous tinge; scutellum ochraceous; elytra black except at extreme edge bordering scutellum, which is ochraceous; ventral surfaces of body orange testaceous with a slight ochraceous tinge; femora and bases of tibiae reddish ochraceous,

remainder of legs black with heavy dull golden brown hairs; tarsal claws pitchy red. Body surfaces largely clothed with pale golden buff pubescence; elytra thinly clothed with reddish black pubescence and with a few fine suberect black hairs basally.

Head not quite as broad as prothorax, coarsely and densely rugose-punctate, depressed and grooved between antennal insertions and slightly raised between superior eye-lobes. Antennae about four-fifths as long as body, moderately stout, slightly compressed; scape not quite as long as third segment; third a little longer than fourth; following segments gradually decreasing in length. Prothorax slightly more than one-third again as broad as long, heavily and somewhat closely punctured; sides broadly and bluntly swollen; disc evenly convex except for an upward prolongation of each lateral swelling near posterior margin. Scutellum broader than long, declivitous, slightly emarginate-truncate apically, minutely punctured. Elytra broadest at base, feebly narrowed in central portion and very slightly broadened preapically; apices narrowed and obliquely subemarginate-truncate; surface of each deeply impressed with subrounded punctures arranged in about ten irregular longitudinal rows, the punctures becoming smaller and more irregular posteriorly, but extending as far as apices. Ventral surfaces of body heavily punctured at sides of metathorax and first abdominal segment, much more finely punctured towards apex of abdomen. Length 22.4 mm.; breadth 4.8.

The holotype, a female, is in the collection of the College of Agriculture, University of Nanking. This species was rather briefly diagnosed in the original description.

Differs from *Linda atricornis* Pic in being larger and of much stouter build, in having the head and pronotum more densely punctured, the elytra with less regular puncturation and with round instead of square punctures, and in having the sutural borders of the elytra, and the femora entirely, ochraceous. This is probably the largest species of the genus.

*Distribution:* Anhwei (Hwang Shan<sup>1</sup>).

#### 11. *Linda nigriventris* Heller

*Linda nigriventris* Heller, 1923, Ent. Blatter 19: 74<sup>1</sup>; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 41.

Black; prothorax, scutellum, apical fifth and lateral margins of elytra, femora, mesosternum, half of middle femora, base of posterior coxae, and last abdominal segment entirely, testaceous. Body extremely narrow; head black, dark brown behind vertex, clothed with rows of black, suberect hairs, coarsely seriate-punctate, a row of large punctures fringing superior eye-lobes; third to eighth antennal segments briefly white basally; prothorax coarsely punctured except for a series of swellings forming an arched transverse row, outer posterior tubercle clothed with fine white hairs; scutellum yellow, impunctate; elytra coarsely punctured between three impunctate costae, outermost costa joining external margin, punctures disappearing before apices, black, brownish along suture, becoming testaceous posteriorly, joining testaceous marginal stripes before apices, leaving black portion of each rounded behind; ventral surfaces black, pro- and mesosterna, entire

anterior, and bases of middle and posterior, femora, and last abdominal segment, testaceous. Length 19 mm.; breadth 4.5. (After Heller).

*Distribution*: Szechuan (Kwan-hsien<sup>1</sup>); Sikang (Ta-t sien-lu<sup>1</sup>).

## 12. *Linda nigroscutata* (Fairmaire)

(Fig. 3)

*Miocris nigroscutatus* Fairmaire, 1902, Bull. Soc. Ent. France: 245<sup>1</sup>.

*Linda nigroscutata*, Beeson & Bhatia, 1939, Ind. For. Rec., Ent. (n. s.) 5: 130<sup>2</sup>;  
Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

Body bright orange-red; antennae, eyes, labrum and legs black; pronotum with four small round black spots in form of a trapeze on disc; elytra with an elongate scutum-shaped black mark behind scutellum, reaching to end of basal quarter or basal third of suture, and the humeri generally also marked with a black spot; metathorax and abdomen largely black, but with posterior border of each sternite, and most of last abdominal sternite, orange. Antennae four-fifths as long as body in male and two-thirds as long as body in female; prothorax strongly swollen at each side and on center of disc; elytra broadened preapically and rounded apically, impressed with numerous close, irregular punctures, and with three feeble longitudinal costae on each. Length 15.8–19.6 mm.; breadth at humeri 3.5–4.4.

Numerous specimens (Tsing-hua Univ.; Lingnan Nat. Hist. Mus.) were reared from apple at Kunming (Yunnan-fu), alt. 6000 feet, Yunnan Prov., S. W. China, May and June, 1940, by Mr. Ying-tou Mao.

*Host plant*: *Pyrus malus*<sup>2</sup> (Apple).

*Distribution*: Yunnan (Mouy-tse<sup>1</sup> and Kunming); Assam<sup>2</sup>.

## 13. *Linda pratti* Pic

*Linda pratti* Pic, 1902, L'Echange 18 ("17"): 3<sup>1</sup>; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10<sup>1</sup>; 1942, *ibid.* 8: 41.

Dull, clothed with a yellow and gray pubescence (much reduced on pale areas); black and testaceous; most of anterior portion of body and ventral surfaces testaceous: head broad, marked with black on antennal supports and behind eyes; vertex grooved; frons convex; eyes black; mandibles and apex of labrum dark; antennae not reaching elytral apices, attenuated, black, more or less testaceous at bases of fourth, fifth and sixth segments; prothorax entirely testaceous, short, margins sinuous, moderately swollen below middle of each side, behind which there is a groove, disc with a feeble longitudinal carina; scutellum broad, with testaceous pubescence; elytra black, slightly broader than prothorax, weakly constricted at middle, emarginate apically, with external angles prominent, surfaces with strong punctures subregularly arranged in longitudinal series, lacking distinct costae; wings dark; pygidium testaceous; ventral surfaces of body entirely testaceous; legs black with bases of femora, and sometimes bases of tibiae, more or less testaceous. Length 17 mm. (After Pic).

*Distribution*: N. Kiangsi (Kiukiang<sup>1</sup>); Kiangsu (Nanking<sup>2</sup>).

There is little in the original description of this form to separate it from *fraterna* and it may possibly prove to be a subspecies or synonym of the latter.

14. *Linda signaticornis* Schwarzer

*Linda signaticornis* Schw., 1925, Ent. Blatter 21: 154<sup>1</sup>.

Head, prothorax, scutellum and ventral surfaces reddish yellow, except for a blackish area on part of metasternum; elytra and legs black with basal half of fourth segment reddish yellow and extreme base of fifth grayish. Head closely and strongly punctured; pronotum finely and sparsely punctured; both with fine grayish pubescence; scutellum truncate apically, transverse; elytra closely and subregularly punctured, obliquely truncate apically. Length 13 mm.

Several specimens (California Academy of Sciences) were taken in southern Formosa by the writer.

*Distribution:* Formosa<sup>1</sup> (Kosempo, Kankau, Sokutsu, Kusukusu).

15. *Linda tricastata* Gressitt, new species

*Male*.—Dorsal surfaces largely pale, antennae black and ventral surfaces pitchy: head and prothorax pale reddish ochraceous, mouth-parts and prosternum pitchy black; antennae completely black, non-annulated; scutellum ochraceous; elytra orange testaceous, pitchy black on humeri; ventral surfaces largely pitchy, but with scattered areas of reddish brown or ochraceous; abdomen largely pitchy brown; legs blackish, anterior femur largely testaceous, the other femora pitchy. Dorsal surface clothed with thin pale pubescence and erect brownish to pitchy hairs; ventral surfaces with reddish to golden pubescence; antennae with close pitchy pubescence.

Head not quite as broad as prothorax, feebly convex in front, slightly concave between antennal insertions, grooved on vertex and occiput, rather coarsely and in large part closely punctured. Antennae not quite as long as body, moderately stout, most of segments slightly expanded ectoapically; scape not quite as long as third segment; third distinctly longer than fourth; fourth to tenth gradually decreasing in length, last cylindrical and suddenly acuminate distally. Prothorax nearly one-third again as broad as long, narrower at apex than at base, distinctly and evenly swollen at sides; disc with four feeble swellings; one on each side of center, one at center and one behind center; surface coarsely and in part closely punctured. Scutellum trapeziform, slightly swollen in center, truncate posteriorly. Elytra narrowest somewhat behind middle, apex of each gradually and obliquely narrowed externally and suddenly oblique internally, forming a rounded-obtuse angle; surface deeply, coarsely and closely punctured in about ten irregular rows divided in four areas by three costae, the punctures mostly separated by less than their diameters. Ventral surface somewhat heavily punctured at sides of hind thorax and first abdominal segment. Posterior femur reaching just beyond end of second abdominal sternite. Length 15.3 mm.; breadth 3.3.

*Holotype*, male (No. 58,339 U. S. Nat. Mus.) Kunming (Yunnan-fu), Yunnan Prov., S. W. China, Aug. 1, 1944, Dr. Liu Chung-lo (C. L. Liu) (Exper. No. 2218).

Differs from *L. nigroscutata* (Fairm.) in lacking the dark mark behind scutellum and in having the pronotum entirely pale.

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## BOOK NOTICES

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CHRONICA PALMARUM, P. LEPESME, Editor-in-Chief, PAUL LECHEVALIER, Publisher.

The review copy of *Les Insectes des Palmiers*, discussed above, was accompanied by an announcement of a new periodical under this title. The editor promises original studies of the botany of palms and their animal associates, miscellaneous observations and notes and bibliographic materials. The first volume is to appear in 1948. Articles on the classification of the palms, on the nematodes attacking palms and on insects inhabiting palms are mentioned as part of the contents of this volume. We extend our best wishes to the publisher and editor for the success of their venture. The subscription price is not mentioned.

—A. W. L.

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LES INSECTES DES PALMIERS, by P. LEPESME with the assistance of J. BOURGOGNE, E. CAIRASCHI, R. PAULIAN and A. VILLIERS. 903 pages, 638 figures, 1947. Published by Paul Lechevalier, Paris. Price not given.

The value of this volume to North American entomologists is problematical since the distribution of palms in our area is so limited, but as a contribution to the entomology of warmer lands it is monumental. The reviewer knows next to nothing about palms, but he would hazard the opinion that this book is an exceedingly comprehensive survey of the insect enemies of these plants in all parts of the world.

The book includes three principal divisions. Part one is designated as a biological analysis of the synecology of the insects and palms, part two as a systematic study of the entomological fauna of the palms and part three is devoted to injurious insects, their damage and means of control.

Part one offers much interesting biological material. In part two the reviewer has found his own special group, the Hesperioidea, treated very informatively, hence he concludes that other taxonomists may find the survey useful. Part three is, of course, the most important section for economic purposes. It is the shortest part of the book, including only seventy pages. Spraying, dusting and mechanical measures of control are discussed, but the section leaves the impression that newer chemical agents for the control of insect pests have not yet been extensively used in this field. It should offer an important opportunity.

The book is well printed and the line cuts are excellent. Half-tones leave something to be desired. They are not especially poor but neither are they of really high quality.

In their general introduction the authors state that one of their number was vividly impressed with the lack of a general work on palm insects while on an entomological mission in equatorial Africa. They have abundantly corrected that lack in this excellent work.—A. W. L.

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SPECIFICITY OF MANTID OOTHECAE<sup>1</sup>

(Orthoptera: Mantidae)

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It has been known for some time that features other than the morphological characteristics of adult organisms are of importance in distinguishing between species, and in determining group relationships. Criteria that have been thus used include the structure of eggs and immature stages, physiological reactions such as the host specificity of parasites, and various physiological products such as the galls of some insects.

The senior writer's attention was first attracted to the possible significance of mantid oothecae or egg cases several years ago when he was investigating the biology of mantid egg parasites (Breland, 1941a). During the course of this study, it became evident that the type of egg mass produced by the different species of mantids varied considerably. An abstract of some observations in this connection was published (Breland, 1941b) and since that time, additional correlations have been made. Although photographs of the oothecae of several species of mantids have been published (Rau and Rau, 1913; Jones, 1933; Roberts, 1937a) so far as could be determined, there has never been a serious attempt to use these physiological products in taxonomic studies.

The following native species are dealt with in this paper: *Stagmomantis carolina* (Joh.), *S. californica* Rehn and Hebard, the *Limbata* complex (two species), *Brunneria borealis* Scudd., *Litaneutria minor* (Scudd.), and *Phyllorates chlorophaea* (Blanchard). It will be noted that two species are designated as the *Limbata* complex. The adults of these mantids are apparently not separable from each other in

<sup>1</sup>Supported by University Research Institute.

<sup>2</sup>The writers wish to express their appreciation to Mrs. Sarah Martin, who made the drawings for Plate I, and to Messrs. A. B. Gurney and James A. G. Rehn, who determined the adults of the mantids mentioned in this paper, and who gave assistance in mantid nomenclature.

small series, and at the present time, both groups are considered to be *Stagmomantis limbata* (Hahn). The writers will shortly present evidence to support the contention that two species are involved. The type locality of *S. limbata* was simply stated to be "Mexico," and both species being considered in this paper probably occur in that country, since egg masses of both have been collected along the Texas border. It is thus not believed that at the present state of our knowledge the specific name *Stagmomantis limbata* (Hahn) should be applied to either species to the exclusion of the other.

Three introduced mantids, well established in the northeastern part of the United States, are also briefly considered for purposes of comparison. These include *Tenodera angustipennis* Sauss., *Tenodera aridifolia sinensis* Sauss., and *Mantis religiosa* L.

#### METHODS

During the course of this study which has extended over a period of several years, the writers have collected and examined hundreds of mantid egg cases. These collections have extended over most of Texas, and in some instances into adjoining states. In addition, collections of oothecae have been received from several individuals in other regions. Nine species of mantids have been stated to occur in Texas (Hebard, 1943), the native species listed above, and *Oligonicella mexicana* (Saussure & Zehntner), *Oligonicella scudderi* (Saussure), and *Yersiniops solitarium* (Scudder). The writers have not collected any egg cases of these three latter species, but have large series of the oothecae of the other mantids known to occur in the state.

Two methods were employed in determining the type of egg case produced by each species of mantid. One procedure was to collect adult females and keep them in the laboratory until they deposited egg masses. The oothecae thus produced were in most instances comparable to those deposited in nature. The principal differences in cases that were deposited in the laboratory as opposed to those produced in nature were in size and color. Oothecae that were deposited within a few days after the mantids were brought into the laboratory were usually of average size, but if the insects produced several cases, those deposited after a few weeks of laboratory residence were frequently smaller than the egg masses collected in the field. Laboratory produced oothecae were sometimes lighter in color than those deposited outdoors and exposed to climatic conditions.

In the laboratory the adult mantids were confined in bell jars 8 to 10 inches high and 8 inches in diameter. Several sheets of toweling paper were placed between the jars and the table upon which the jars rested. Within each jar was placed a small twig one-fourth to one-half inch in diameter, one end of which rested on the table while the other end leaned against the side of the jar. These slanting twigs furnished a place for the insects to rest, and they were usually used as a substratum for egg case deposition. A few drops of water were added each day to the toweling paper, and at least one living insect per day was introduced into each bell jar. Additional details of methods used in keeping living mantids in the laboratory may be found in a former paper (Breland, 1941c).

The females of *Stagmomantis carolina* seemed to react considerably better to laboratory conditions than did the females of other species, but the writers may have received the wrong impression since many more specimens of this species were used. As has been stated previously (Breland, 1941c), a large number of females of *S. carolina* have been kept for months in the laboratory, during which time most of the insects deposited several egg masses. Other mantids would frequently survive for several weeks, but aside from *L. minor*, these insects seldom produced more than a single normal case. Several females of *L. minor* have deposited two or three normal oothecae.

It was not possible to obtain living females of all species of mantids that were studied, and for these species, egg cases were collected, allowed to hatch in the laboratory and some of the young mantids were reared to maturity. A majority of the egg masses apparently hatched sooner under laboratory conditions than they would have normally, and in some instances, nymphal emergence was probably hastened by as much as two or three months.

As might have been expected, the nymphs of most species were intensely cannibalistic, and for this reason they were placed in individual containers. These containers consisted of small salad dressing jars of various sizes which were covered with tin tops through which holes had been punched. Toweling paper or a small twig was placed within each jar, since it was found that some type of substratum was essential to successful ecdysis. As a rule, the old skin remains attached to a substratum while the insect emerges therefrom, and without something that can be successfully grasped, the young mantid almost invariably dies during the process.

Drops of water were added daily to these individual containers, and the small mantids were fed on fruit flies kindly supplied by the geneticists of the Department of Zoology. As the mantids grew, they were transferred to larger containers and fed larger insects, and during the next to last instar, each specimen was placed in a bell jar of the type previously described.

#### THE OOTHECAE

The egg masses of the same species will, of course, vary somewhat in color, size and shape, but of the egg masses examined there has seldom been any doubt as to the species to which the case should be assigned. Of the hundreds that have been collected, less than a dozen have been so abnormal that uncertainty existed as to the species of mantid which produced them.

The actions of *Stagmomantis carolina* in depositing the oothecae, and the general structure of the egg masses have been previously described (Rau and Rau, 1913; Breland, 1941c). The methods of other species of mantids that the writers have observed producing egg masses conform in general to those of *S. carolina*.

Despite differences among the various oothecae that have been studied, they are all similar in fundamental structure. A brief consideration of the general structure of egg cases will be of assistance to the reader in understanding the terminology that is used for the various parts (Plate I).

The side attached to the substratum is designated as the ventral or basal surface, while the opposite side is the top or dorsal surface. The two ends of the cases are usually somewhat different in size and shape. In some, one end is slightly larger than the other, and the surface of this large end is frequently more vertical than is the surface of the other end. Since the mantid starts the case at the large end, this region is called the anterior end, while the opposite end is posterior (figure 1, Plate I). At the anterior end of the egg masses of some species, there is a small band of material extending ventrally that partially or completely surrounds the small twigs or weeds to which the oothecae are attached. This encircling band is broken if the case is pulled from the substratum.

In most species, there is a rather large emergence area on the dorsal surface, from which the young mantids emerge in the spring (E, Plate I, figure 1). The appearance of this region varies considerably, depending upon the species, and upon the time of year that the oothecae are collected. When the egg cases are first deposited, the emergence area is frequently partially filled with a whitish deposit which for a time covers the newly formed cases. This material gradually disappears as the oothecae are exposed to the weather, so that within a few months a series of partial or complete transverse slits may be seen in the emergence areas. These slits are separated by partitions of various lengths, depending upon the species of mantid. The ventral part of the emergence area is in connection with the dorsal ends of the eggs inside the case so that the young mantids issue from this region upon hatching. This connection between the emergence area and the ends of the eggs can best be seen in cross or sagittal section (Plate I, figures 3 and 4). The oothecae of all species studied, with the exception of those of *Brunneria borealis*, exhibit an obvious emergence area. The absence of this region in this species, as explained below, is one of the most interesting modifications discovered during this study.

In order for one to appreciate fully the complex structure of an ootheca, it is necessary to make sections of the cases in several planes and at a number of levels. The eggs within the case stand on end, and occur in rows. Each egg is enclosed within a cell, the walls of which have a tendency to form a hexagon, and this shape may be observed in a frontal section of the case which forms a transverse section of the individual egg cell. If a frontal section is made through an ootheca near the base (Plate I, fig. 2) it will be noted that the zig-zag partitions formed by the cell walls may be traced both lengthwise and transversely across the case.

The organization of the egg cells varies somewhat with the different species of mantid, but there are usually at least a few rows of cells that

#### EXPLANATION OF PLATE I

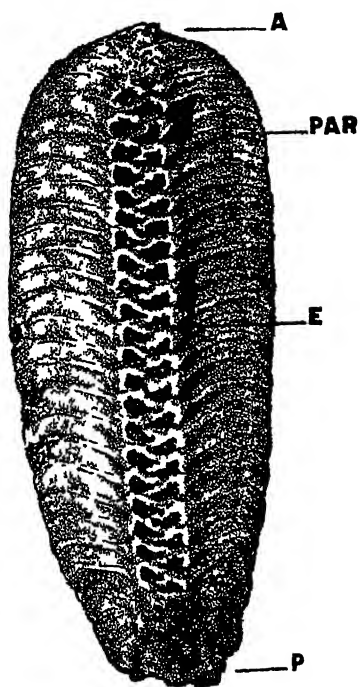
Structure of mantid oothecae. FIG. 1. Dorsal view of complete case. FIG. 2. Frontal section near ventral surface. FIG. 3. Sagittal section. FIG. 4. Transverse section near center of case.

##### ABBREVIATIONS

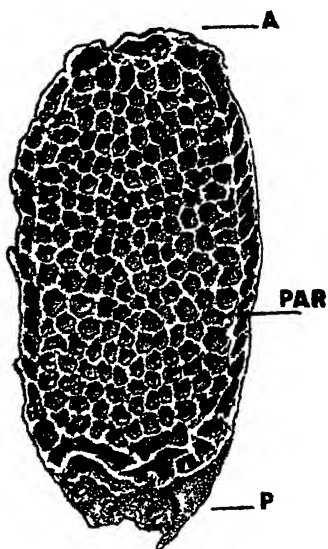
A—anterior end.  
C—egg cell.

E—emergence area.  
P—posterior end.

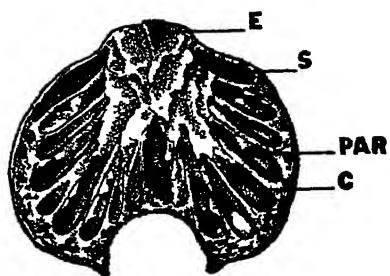
Par—partition.  
S—air space.



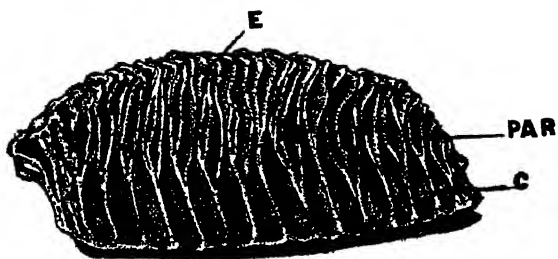
1



2



4



3

are perpendicular to the dorsal and ventral surfaces of the case. This alignment can best be seen in a cross or transverse section of the egg mass (Plate I, fig. 4). In this type of section it may also be noted that the dorsal ends of the egg cells are in contact with the ventral portion of the emergence area, and this fact may also be observed in a sagittal section (Plate I, fig. 3).

A varying amount of ootheca material completely encloses the mass of eggs. In some species, this material between the outer tiers of cells and the outside of the case may be quite thick, and in some instances, relatively large air spaces may occur in this area laterally and dorsally (S, Plate I, fig. 4). This type of air space usually extends almost the complete length of the oothecae. In some species the material surrounding the eggs possesses a large number of air spaces throughout its substance which causes the sides of the oothecae to be quite soft.

The substratum to which the egg masses are attached is apparently one of the most important factors that influence variations in the size and shape of many species. As a rule, an ootheca deposited upon a small twig is narrower, higher and longer than one attached to a broad surface such as a fence post or the side of a building.

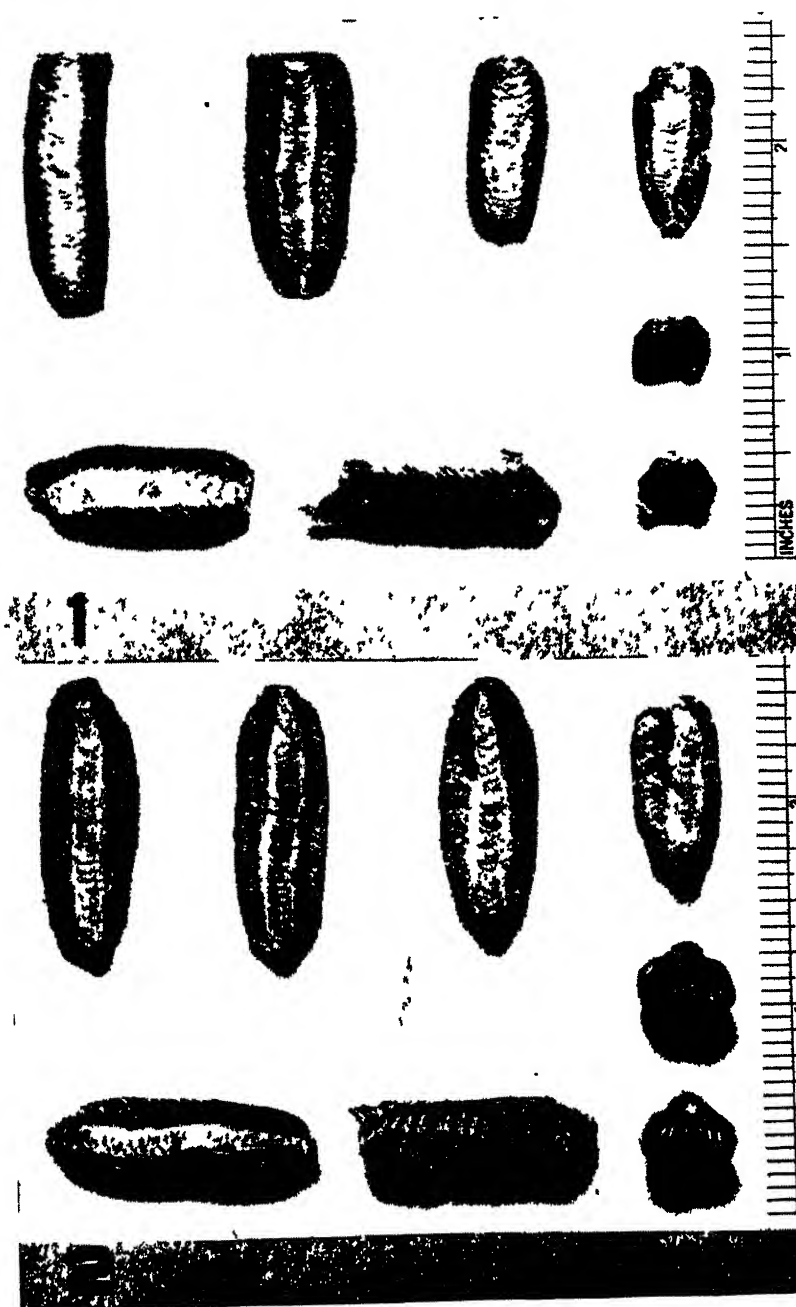
The egg masses of some species will vary somewhat in color depending upon their age. When oothecae are first produced, they are usually covered with a whitish deposition which gradually disappears in nature as the cases are exposed to the weather. If collections are made shortly after the masses are produced, the presence of this material causes many species to appear lighter in color than if they are collected a month or so later.

An even more striking color variation that is apparently dependent upon environmental factors, has been observed for some species. This variation and the possible influencing factors are discussed later in more detail.

Unless otherwise indicated in the legends of the photographs, all the oothecae of each species that are reproduced are from the same locality, and are of egg cases collected in nature. Although a series from the same locality does not always exhibit all the variations of size and shape that may be found for a particular species over its entire range, it is believed that such photographs will have a more permanent value. If some of the species which are at present recognized should, in the future, be divided into two or more species, the plates will still be of some use. Specific collection sites are given in all instances. All the photographs are of old cases from which the young mantids have emerged, or in which the eggs did not hatch and from which, in sections, the egg material has been removed. It is almost impossible to cut a section through an egg case containing viable eggs without breaking some of the egg membranes, thus allowing the liquid to flow over the exposed surface obscuring part of the fundamental structure.

#### EXPLANATION OF PLATE II

Mantid oothecae. FIG. 1. Oothecae of *Stagmomantis carolina* (Joh.). Collected 15 miles west of Canyon, Texas. FIG. 2. Oothecae of *Stagmomantis californica* Rehn & Hebard. Collected 45 miles west of Fort Stockton, Texas.





*Stagmomantis carolina* (Joh.)

The oothecae of this mantid (Plate II, fig. 1) are doubtless familiar to many biologists, since it is the commonest species in many areas, and since its known distribution covers much of the eastern United States.

Photographs of the egg cases of this species have been previously published by Rau and Rau (1913). As indicated before, the substratum upon which the masses are deposited influences the size and shape of the resulting case. The above writers state that most of their material was collected from fences, and the shape of the oothecae which they illustrate is typical of those collected by the writers of the present paper from flat surfaces. The broadest case of this species illustrated in this paper (Plate II, fig. 1) was also collected from a fence post, but all the others were found on twigs. Most of these oothecae thus differ somewhat in shape from those photographed by Rau and Rau.

The oothecae of *S. carolina* are more slender, and on an average are smaller than those of other species of *Stagmomantis* that were studied. The color of the cases varies somewhat depending upon the area in which they are deposited. They are frequently of a brownish grey color, but in some localities, they may be a light brown or orange color. The latter color is especially prevalent in western Texas, and as will be indicated later in the discussion of the oothecae of the *Limbata* complex, this color variation may be influenced by humidity.

In cross section it will be noted that most of the egg cells are practically at right angles to the dorsal and ventral surfaces of the case. Most of the inside of the ootheca is occupied by the egg cells, the eggs, the partitions and other supporting material so that laterally the air spaces between the outer row of cells and the outside of the case are quite small.

*Stagmomantis californica* Rehn & Hebard

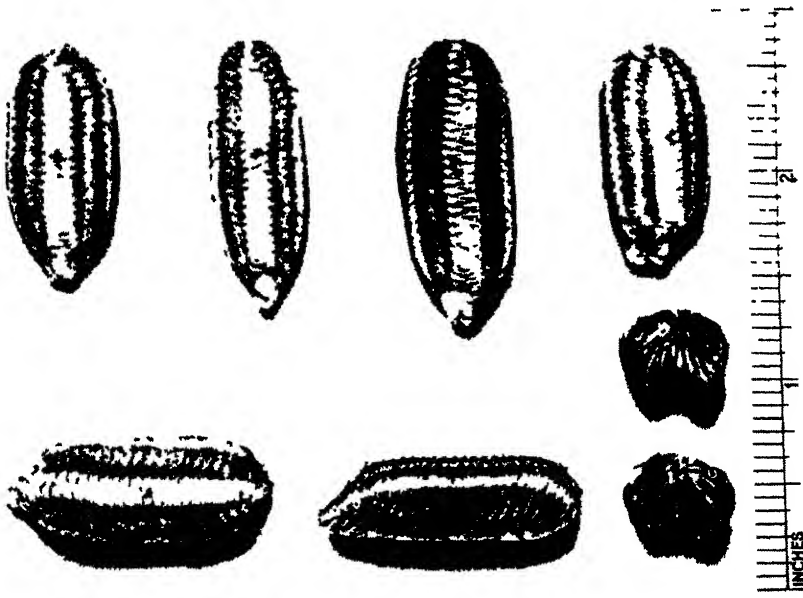
The oothecae of this species (Plate II, fig. 2) are similar to those of *S. carolina*. The egg cases of the two species are distinguishable, however, and those of *S. californica* that have been collected will average somewhat larger than the egg masses of *S. carolina*. The color of the ootheca of the former species varies from a light brownish yellow to almost white. The outstanding external feature of the egg masses of this species is a series of overlapping projections that occur on the dorsal side of the case in the emergence area. These flaps are inclined toward the posterior end of the case, and in freshly deposited oothecae the structures are tightly applied to the surface so that they are not obvious unless some of the white deposit covering the case is removed. The flaps become evident, however, if the finger nail is scraped across the top surface toward the posterior end, or if a longitudinal section of the case is made. In section it may be noted that these flaps are dorsal extensions of transverse partitions.

## EXPLANATION OF PLATE III

Mantid oothecae, *Limbata* complex. FIG. 1. Species 1. Collected 14 miles south of Alpine, Texas. FIG. 2. Species 2. Collected 30 miles south of Palfurrias, Texas. ▲



1



2

A cross section of the case of this species greatly resembles that of *S. carolina*. The cells are essentially perpendicular to the top and bottom of the ootheca, although there is in some instances a tendency for the outer rows to depart slightly from the vertical. The outer layer is thin, and the air spaces in this region are small. The oothecae are not quite as compact as are those of *S. carolina* and the sides may be slightly indented with a little pressure.

### The Limbata Complex

It was previously indicated that the writers have considerable evidence that the mantids in Texas now recognized as *Stagmomantis limbata* (Hahn) should be considered as two distinct species. The oothecae of the two groups (Plate III) while similar are separable. Females of both mantids have deposited egg cases in the laboratory, and the differences between these oothecae are as great as between those collected in nature. Environmental influence upon the egg cases could thus not alone account for the differences between the two types.

Nymphal emergence from both types of egg cases have been observed from many localities. The first instar nymphs of one species are invariably green in color, while those of the other group are always brown. Nymphal emergence from a few laboratory deposited egg cases has occurred, and in all instances, the color of the nymphs were as indicated above. It has been previously recognized that the same species of mantid may include both grey and green adults, and that a long series may show all gradations between the two colors (Rau and Rau, 1913; Rehn, 1935). For this reason, the color of the adults of mantids is of doubtful significance in distinguishing between species. So far as could be determined, very little work has been done upon the significance of color of the first instar nymphs, but certain observations support the conclusion that the color of this stage is more constant than in the adults (Rau and Rau, 1913; Roberts, 1937a). Since the writers have never found an exception to the color difference between the nymphs hatched from the two types of egg cases, they feel that this difference, as explained above, should be regarded as additional evidence that the two mantids are not the same.

According to oothecae records, these two mantids have a different distribution, and as yet the two types of cases have never been collected at the same locality.

Many species of mantids are notoriously variable in adult structural characteristics, and for this reason, the writers do not feel that they at present possess series of adults large enough to warrant positive statements regarding possible differences between the two groups. Numbers, rather than specific names are thus applied to each group. The following designations are used in the present paper:

SPECIES 1. Collections of oothecae indicate that this mantid occurs in most of west Texas, west of the 98th parallel of longitude. No oothecae have been collected east of this line. Representative collections of the egg cases of this species include: Electra, in Wichita County; Lubbock, Lubbock County; Seminole, Gaines County; Carlsbad, New Mexico; Fort Davis, Jeff Davis County; several

collections in Brewster County in the Big Bend area, and Del Rio, Val Verde County. The nymphs of this mantid are brown in their first instar. The egg masses are figured in Plate III, fig. 1.

SPECIES 2. This species is at present known only from southeast Texas, from San Antonio south and east to Brownsville. Collections of the oothecae of this mantid include San Antonio, Bexar County; Beeville, Bee County; Alice, Jim Wells County; Falfurrias, Brooks County; and Brownsville, Cameron County. The nymphs of this species are green in the first instar. The egg masses are illustrated in Plate III, fig. 2.

SPECIES 1. The oothecae of this mantid (Plate III, fig. 1) are easily distinguished from those of *S. carolina* and *S. californica*, since the former are larger and of a different shape.

The color varies from orange to black. Cases collected in central Texas have almost invariably been black, while those from west Texas have been orange in practically all instances. Not more than a half dozen of the several hundred oothecae of this species that have been collected have been exceptions to this rule. The difference between these two colors is so striking that when the writers first collected the orange colored cases they thought it probable that a species different from the black cases was involved. The orange colored cases were kept in the laboratory for a time, and the writers found to their amazement that most of the oothecae darkened perceptibly, and some eventually became almost as dark as those collected in central Texas. This color change was noticeable after the oothecae had been in the laboratory for 24 hours, but most of them darkened considerably after this time. Old cases, or those collected relatively late in the season (after December) apparently do not possess the capacity for color change, since no noticeable darkening has been noted in oothecae that have been collected after the above date.

Although all the factors that may influence the color difference or that may have caused the darkening of the light colored cases are not known positively, it is thought probable that relative humidity and temperature may have been contributing factors. Most of the orange colored cases have been collected in areas where the rainfall is less than in the regions where the dark oothecae occur. Relatively high humidity in the Austin area, or the higher laboratory temperatures may have influenced the change in color.

An examination of the cross section reveals that only the middle tiers of cells are vertical with respect to the dorsal and ventral surfaces of the oothecae, while rather large air spaces occur dorsal and lateral to the outer layers of cells.

SPECIES 2. The oothecae of this species (Plate III, fig. 2) vary from a light to a dark reddish brown with an occasional specimen almost black. When these oothecae are first produced, the usual white deposit almost covers them. As the cases are exposed to the weather, most of the white material disappears except for two lateral longitudinal stripes, one on each side of the case near the top. These stripes are quite persistent in many instances, and may even be present in egg cases that have been exposed to climatic conditions for over a year. These white

stripes are absent or very faint in the oothecae of species 1, since in most instances, the whitish material disappears entirely after the cases have been exposed to the weather for a short time. The persistent white stripes of species 2 may be noted in Plate III, and it may also be seen that there is a difference in the shape of the two types of cases. Those of species 2 are on an average more slender and are not so high as are the oothecae of species 1.

In cross section, the arrangement of the egg cells is seen to be similar to that of species 1. Only the middle cells are perpendicular to the top and bottom of the case, while those on each side occur at an angle. Small air space may be noted lateral to the emergence area, and dorsal to the egg cells.

Roberts (1937a) studied the biology of a mantid which was determined as *Stagmomantis limbata* (Hahn), and the egg cases that were used in the investigation were collected in Arizona. The ootheca figured in this paper, and the description of the nymphs that emerged during the study closely resemble the oothecae and nymphs of species 2 of the present paper. It may be that these two species are the same, but further study must be completed before this fact can be determined with certainty. The fact that species 2 apparently does not occur in west Texas may be considered as some evidence that this species and the mantid studied by Roberts are not the same, but in Mexico the distribution of the two may be continuous or nearly so.

#### *Brunneria borealis* Scudd.

The oothecae of this species (Plate IV, fig. 1) differ radically from those of the mantids previously discussed. They are relatively small, are laterally compressed and they possess a definite dorsal point on the posterior end. The cases are quite compact and are noticeably harder than those of most species.

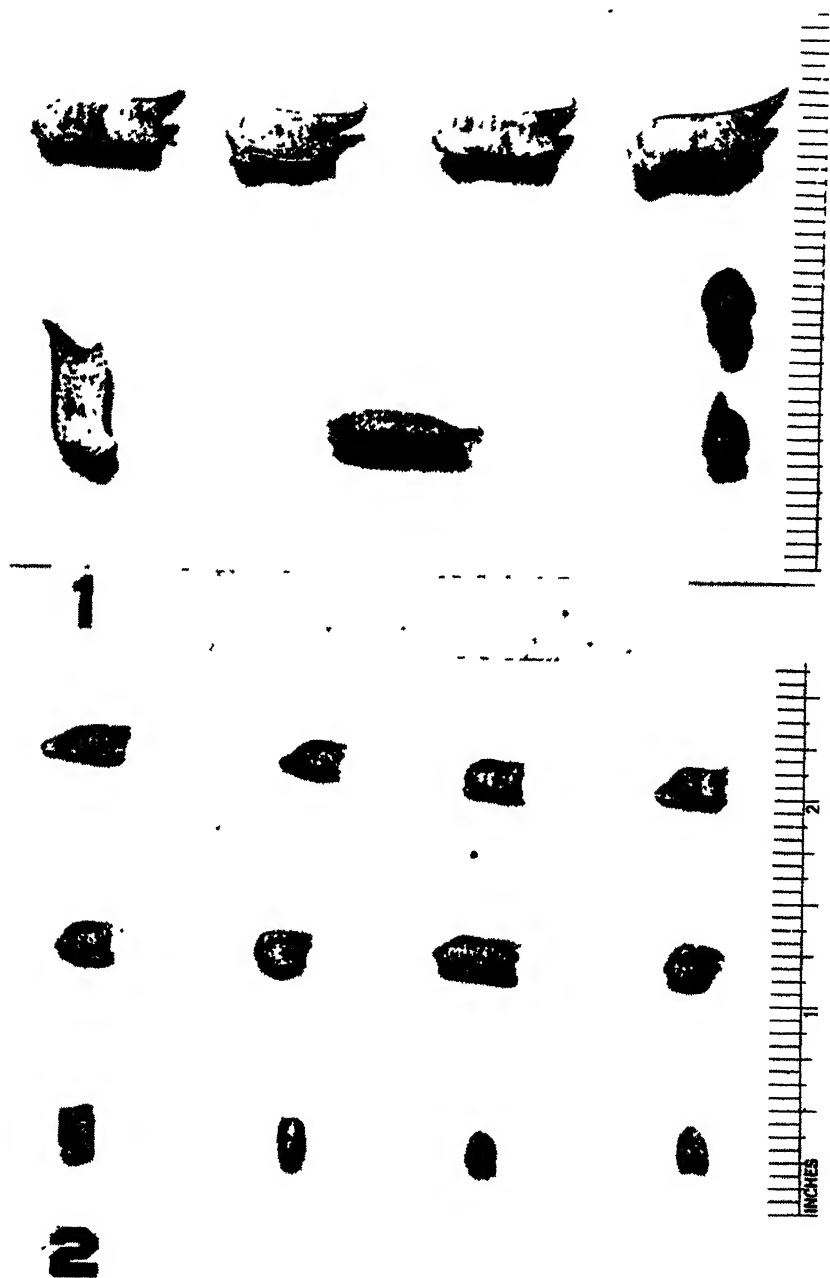
An interesting feature of this case is the presence of a ventral band of material on the anterior end that either partially or completely encircles the twig or weed to which the ootheca is attached. This band was not present in the few cases that the writers have collected from flat surfaces.

Upon hatching the young mantids emerge only from the point at the posterior end, and not from a large area along the dorsal surface as is true for most species. The hollow point connects to an inner cavity above the eggs with which the ends of the eggs are in contact. This modification of the emergence area is one of the most extreme modifications of oothecae that was observed during the entire study.

The egg cases are usually grey in color, but may have a yellowish cast, and they are occasionally almost black.

#### EXPLANATION OF PLATE IV

Mantid oothecae. FIG. 1. Oothecae of *Brunneria borealis* Scudd. Collected 5 miles southeast of Austin, Texas. FIG. 2. Oothecae of *Litaneutria minor* (Scudd.). Egg masses deposited in the laboratory by females collected 10 miles northwest of Burnett, Texas.



The egg cells are perpendicular to the top and bottom of the oothecae, while air spaces are practically non-existent except for the dorsal space mentioned above into which the young mantids issue before they emerge from the hollow tip.

#### *Litaneutria minor* (Scudd.)

This species of mantid produces the smallest oothecae that have been seen by the writers (Plate IV, fig. 2). Only a few of these egg cases have been collected in nature, those that are illustrated having been deposited in the laboratory.

Roberts (1937b) describes the egg masses of this species, and he states that a captive female may deposit as many as ten oothecae. The writers do not have any accurate data as to the number produced by a single female, since because of limited facilities, several mantids were confined within a single container. These mantids survived longer than did most species, aside from *S. carolina*, and they deposited several oothecae while they were in captivity. The egg masses obtained by the writers correspond quite closely to the description of the external structure given by Roberts (1937b). The prevailing color is light brown or grey. Some specimens superficially resemble those of *B. borealis*, since they are laterally compressed, and a small dorsal point frequently occurs on the posterior end. The transverse partitions between the tiers of egg cells are extended dorsally, and these extensions form overlapping flaps in the emergence area somewhat resembling those in the oothecae of *S. californica*. Because of the small size of these cases, and the obscuring of the projections by the whitish substance secreted by the female at the time of egg deposition, the flaps are usually not evident in a newly deposited case unless it is examined with a hand lens or a dissecting microscope. Even with magnification, it is sometimes necessary to probe with a dissecting needle to observe the flaps. The emergence area is enclosed laterally by the projecting sides of the case so that the young mantids emerge at the ventral side of a shallow trough.

In some of the oothecae, particularly those of large size, the anterior portion of the emergence area is covered by the fusion of the two sides, so that these posterior cells do not have an independent opening to the outside. In these oothecae, nymphs emerging from the posterior cells must pass some distance anteriorly before issuing to the outside. There thus appears to be a distinct tendency for the oothecae of this species to approach the condition found in *B. borealis* in which the nymphs all emerge from the hollow point rather than from a large area along the dorsal surface.

An examination of the cross section of the egg case reveals that the egg cells are mostly perpendicular to the top and bottom surfaces, and that air spaces are practically non-existent.

#### EXPLANATION OF PLATE V

Mantid oothecae. FIG. 1. Oothecae of *Phyllopterus chlorophaea* (Blanchard). Collected 6 miles north of San Benito, Texas. FIG. 2. Oothecae of *Tenodera angustipennis* Sauss. Collected at Lancaster, Pennsylvania.





**Phyllovates chlorophaea** (Blanchard)

This species produces an ootheca (Plate V, fig. 1) that is easily distinguishable from those of other species that have been studied. The prevailing color is brown with an occasional specimen almost black.

The method of attachment of this egg mass to the substratum is probably the outstanding characteristic of the oothecae. In all other species that were studied, most of the mid-ventral surface of the egg case was in contact with the substratum. This is even true for the ootheca of *B. borealis*, a species that frequently encircles the supporting twig with a band of material attached to the ventral side of the anterior end of the case. The egg mass of *P. chlorophaea*, however, is attached only by a small portion at the anterior end, while the remainder of the ventral surface is not in contact with the substratum at all. The material of the egg case encircles the twig at the point of attachment. This band, however, does not protrude ventrally to such an extent as does the comparable band on the ootheca of *B. borealis*, but the ventral side of this circlet of material is essentially at the same level as the remainder of the ventral side of the case.

The emergence area occurs upon a definite ridge, while the sides of the case are somewhat projected dorsally on each side to about the same height as the ridge. These projecting sides are the result of enlarged air spaces within the case, and these may be seen in cross section.

In cross section, the oothecae exhibit a distinct wedge shape, with the dorsal region wider than the ventral portion. This size discrepancy is obviously caused by the enlarged dorsolateral air spaces mentioned above. Only the central egg cells are perpendicular to the dorsal and ventral surfaces.

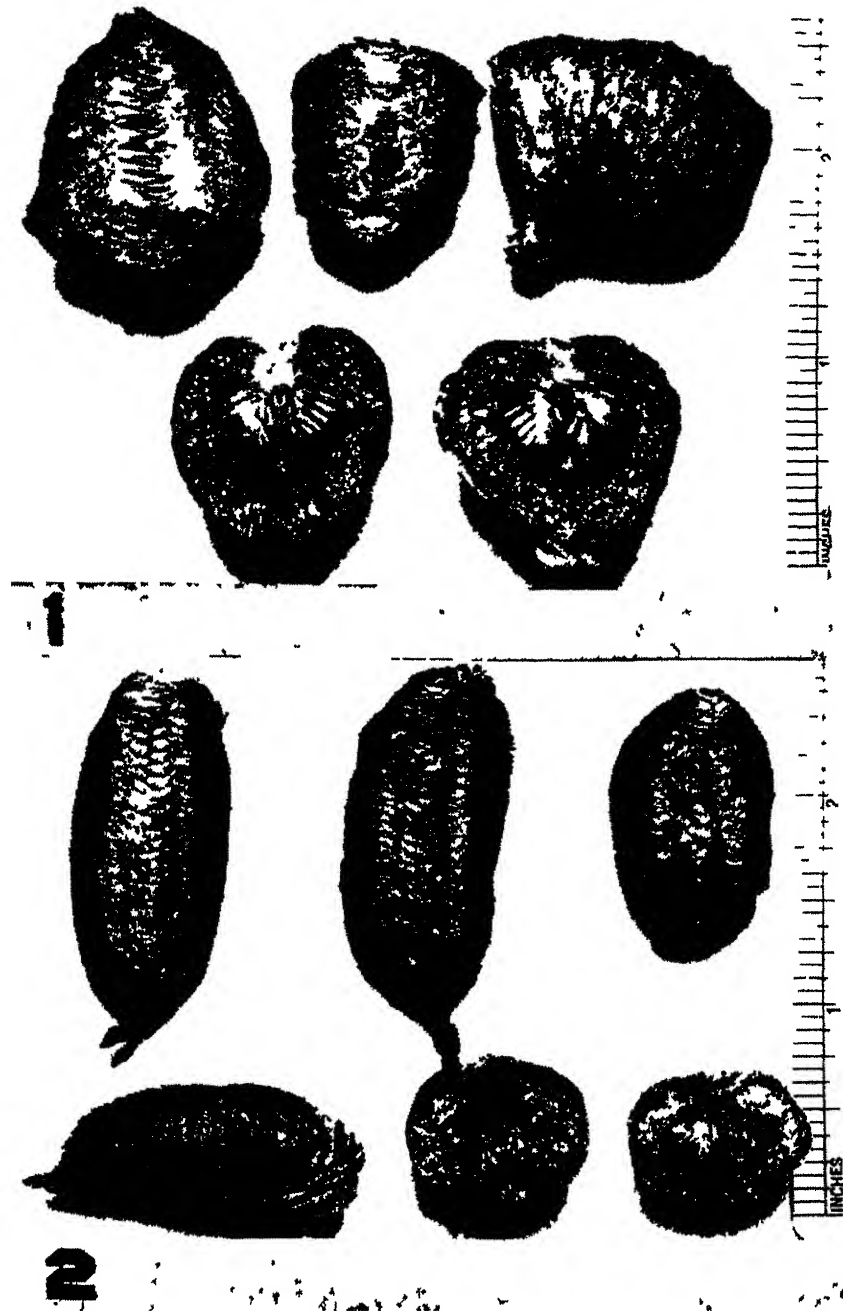
**Tenodera angustipennis** Sauss.

Jones (1933) has published an illustration of the egg masses of this mantid. Superficially, the structures resemble those of *S. carolina*, although the oothecae of *T. angustipennis* (Plate V, fig. 2) are normally larger. There is frequently a relatively long posterior portion of the case that does not contain eggs, a condition not developed to such an extent in the other species examined. The emergence area occurs in a definite ridge that projects somewhat above the sides of the case. The general color is brown, and the oothecae usually possess a dark stripe on each side of the emergence area.

In cross section it is observed that only the center cells are at right angles to the base. Air cells are almost entirely absent so that the structure is quite hard.

## EXPLANATION OF PLATE VI

Mantid oothecae. FIG. 1. Oothecae of *Tenodera aridifolia sinensis* Sauss. Collected at Lancaster, Pennsylvania. FIG. 2. Oothecae of *Mantis religiosa* L. Collected at Rochester, New York.



***Tenodera aridifolia sinensis* Sauss.**

This species produces one of the most outstanding egg cases studied by the writers (Plate VI, fig. 1). The structures have been illustrated by Jones (1933) and many individuals in the East, where the species has become established, are probably familiar with the oothecae. They average larger than the egg masses of any other species that have been examined. The color is greyish to brown, and the shape is somewhat irregular, although there is a tendency for the cases to assume a roughly globular outline. This comparative shape irregularity is probably caused by the numerous small air spaces in the thick outer layer of the case. As a result of these air spaces, which are evident in cross section, the oothecae are soft and the sides are easily indented with a little pressure.

The ootheca is wedge-shaped in cross section with the base being somewhat smaller than the dorsal region. The arrangement of the egg cells is different from that of any of the species previously discussed. As may be noted in the illustration, there is one row of cells arranged in a partial circle around a few that occur at the center of the case. The cells in the middle of the ootheca form two rather definite rows in a dorso-ventral plane. Only a few of the individual cells are vertical, but most of them are arranged at an angle, with the base being near the mid-line and with the remainder of the cell extending upward toward the sides of the case. This is the only species that has been examined in which several layers of cells occur dorso-ventrally, although the center cells of the oothecae of *M. religiosa* exhibit a slight tendency toward this condition.

***Mantis religiosa* L.**

The oothecae of *Mantis religiosa* (Plate VI, fig. 2) are in some respects similar to those of *T. aridifolia sinensis*. The cases are soft as a result of many internal air spaces, and they are easily squeezed between the fingers. The prevalent color is brown.

In cross section, it is seen that the egg cell arrangement is also similar to the condition found in the oothecae of *T. sinensis*. A row of cells partially encircles a few cells in the center. Those in the middle are nearly at right angles to the top and bottom of the case.

**SUMMARY AND CONCLUSIONS**

1. A study of the oothecae or egg cases of several species of preying mantids indicates that the egg cases produced by each of the mantids studied are quite characteristic for the species. Since all available data should be used in taxonomic studies, mantid oothecae should be utilized to the fullest extent in investigations involving this group of insects.

2. At the present state of our knowledge, the oothecae of *S. carolina* appear to be less specialized than those of the other species that were studied. An egg case of this general structure could have been the type from which other forms have been derived.

3. Evidence is presented that the mantids in Texas now recognized as *Stagmomantis limbata* (Hahn) represent two distinct species. Reasons for this conclusion include distinct types of oothecae, nymphs of different color in the first instar and different distributions of the two mantids.

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CHEMICAL INSECT ATTRACTANTS AND REPELLENTS, by VINCENT G. DETHIER. xv+289 pages, 69 figures. The Blakiston Company, Philadelphia, Pa., 1947. Price \$5.00.

The author states his objectives so carefully in his preface that readers are left in no doubt of the nature of this book. Dr. Dethier does not propose a compilation of formulae and methods of application nor a detailed study of the physiology of the insect but attempts "to bridge the borderline between chemoreception and the broader aspects of behavior based upon it."

The book opens with a chapter on the history of the subject. Chapters two to five cover various types of attractants. Chapter 6 deals with olfactometers and threshold concentrations, chapter 7 with baits and traps, and chapter 8 with repellents. In chapter 9 on the chemical basis of taste and olfaction and chapter 10 on the evolution of feeding preferences the author departs from more factual topics to take up those involving difficult interpretation and many unknowns.

The author shows remarkable comprehension of his subject. All parts of his work will offer an abundance of information to the entomologist and most chapters are of considerable interest to biologists in general. The last two especially have broad significance, even though they are based primarily upon insects. They reveal high competence in the handling and interpretation of facts as the preceding chapters reveal the breadth of the foundations on which the book is based.

Each chapter is accompanied by an impressive bibliography and the book concludes with author and subject indices.

In the reviewer's opinion Dr. Dethier has made an important contribution in this study to the development of a precise science of entomology which has been going on during the past few decades. As much of the earlier material based on trial and error and on simple observation has yielded to more elaborate scientific methods our science has become so complex that specialists know less and less of each others' fields. Books like Dr. Dethier's fill an important place in making more up-to-date knowledge conveniently accessible.—A. W. L.

# THE WEIGHTS OF PHYMATA PENNSYLVANICA AMERICANA MELIN (Phymatidae, Hemiptera)<sup>1</sup>

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This study was done simultaneously with that on the weights of *Sinea diadema* (Fabr.) described in number 4 of volume XL of these ANNALS, and followed the same general plan. The four diets used, A to D, are explained in the legends for Tables I and II. The results are presented under the same topics employed for *Sinea* in order to facilitate comparison. The data offered below are derived from daily weights of 40 individuals.

## RESULTS

*Range of Weights of Nymphs.*—In the absence of a balance that permits accurate weights of the newly-hatched nymphs, I employ the single value of 0.0003 gram for all such individuals. As a sort of guess indicated by actual attempts at weighing the nymphs, this figure probably errs on the upper side. Table I presents data which indicate the capacity of the species to vary in weight in accordance with different instars, diets and sexes. The variations are expressed in terms of the average and extreme last daily weights for each instar. It will be seen that an impressive range in weights occurs, even among individuals of one sex and diet. This is most obvious in the fifth instar, where the spread between the lightest and the heaviest individual in each dietary group reaches its peak. In general this spread is greater among the female nymphs; they consume more prey and attain a larger bulk in the course of growth than the males. In their mature state, reached at the end of the fifth instar, the 26 male nymphs in all dietary groups varied from 0.0224 to 0.0258 gram, while the 16 females varied from 0.0334 to 0.0473 gram. In the entire course of development, the male nymphs varied in multiplying their weights between 76 (diet C) and 87 (diet D) times, the females from 112 (diet D) to 159 times (diet B). In terms of percents of average gains from hatching to nymphal maturity, the males ranged between 7,490 and 8,527 and the females between 10,136 to 15,900 percents.

*Range in Weights of Adults.*—The pertinent data are given in Table II. The results are segregated by sex and diet, and expressed in terms of average duration of the adult life, percent of increase or decrease (1) from the first to the last day of adulthood and (2) from the first ten to the last ten days. The most diverse differences in percent of change are obtained when the weights of the first and last days are compared, the males displaying an average gain of 1.36 to

<sup>1</sup>Contribution No. 276 from the Entomological Laboratories of the University of Illinois. This investigation was financed by the Graduate School of the University.

12.5 percent. But when the average weights of the first ten and last ten days are used as bases, the same males lost 4.04 to 5.23 percent of their weights. Similar differentials obtain among the females, although here the results derived from both methods (1 and 2, above) of expressing the range in weights are positive. The percents of loss and gain correlate roughly with the amount of food, duration of adult life, and the number of eggs produced by the females. These numbers embrace both eggs laid and those secured by postmortem dissections.

Regardless of dietary group, the reared males varied in weight from 0.0185 gram to 0.0391 gram, the females from 0.0315 to 0.0628 gram. Invariably the adult weighs least on the first day when it has suffered its extreme from molting and has not yet resumed feeding. The peak weight is attained at various time points in adulthood. If the nymph was underfed, the adult lives only a few days and experiences its maximum weight relatively early. The better to optimally-fed adults achieve their maxima generally after ten days and may reach or approach those figures repeatedly thereafter. In not a few cases, the peak weight is reached after midlife. The females make much larger gains than males when well fed, this apparently being an inherent intersexual difference implemented by the greater avidity characteristics of the females.

*Weight Pattern of the Nymphs.*—The increases and decreases that characterize the weight of nymphal *Phymata* in the course of the instar are essentially the same as occur in *Sinea*. Curves *a* to *e* on figure 1 represent five of the forty individual life histories that were secured in this study; they are not based on the actual or raw weights but on the percents of the daily gains and losses. It will be observed first that the curves for the first instar are identical in all the five instances. They were arbitrarily made so because the balance used was not sufficiently refined to secure accurate weights of the first instar bugs. There is some evidence that *Phymata*, like *Sinea*, does not feed in the first and second days of the first instar. Accordingly the nymph doubtlessly loses some weight during those days, hence the line representing the first day on the curve was made to slope down from the horizontal.

Each instar consists of (1) a feeding-growing phase and (2) a molting phase, with the result that the over-all curve for each instar forms an attenuated capital S. The physiological facts underlying this form of the curve are as follows: the feeding-growing phase begins hours to a day or so after the molt. As a consequence of the semi-dessicated state of the tissues resulting from losses of substances in the molt, the nymph ingests a relatively very large amount of food on the first day of this phase, thereby increasing its weight 60 to 83 percent over that of the previous day. On the second day, intensive feeding continues but at a decreased rate with gains of 12 to 30 percent. On the whole the feeding and gains fall still farther below this on the third and succeeding days of the instar, and eventually are discontinued on the last one or two days preceding the next molt. Because feeding ceases for a period immediately before the molt, the nymph actually loses weight perceptibly at this point of the phase. The feeding-growing phase is here regarded as ending with cessation of feeding and

TABLE I  
GRAM WEIGHTS OF NYMPHS, BY INSTARS, DIETS AND SEXES

Diets	Sex	Num- bers Weighed	FIRST INSTAR			SECOND INSTAR			THIRD INSTAR			FOURTH INSTAR			FIFTH INSTAR		
			Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights	Average of Last Weights	Low and High Last Weights
A	♂	8	0.0010	0.0007 0.0014	0.0020	0.0016 0.0026	0.0055	0.0042	0.0055	0.0068	0.0137	0.0137	0.0110 0.0166	0.0244	0.0193 0.0276	0.0244	0.0193 0.0276
B	♂	4	0.0008	0.0007 0.0009	0.0021	0.0018 0.0023	0.0054	0.0049	0.0057	0.0057	0.0127	0.0127	0.0116 0.0136	0.0245	0.0238 0.0285	0.0245	0.0238 0.0285
C	♂	3	0.0008	0.0007 0.0009	0.0020	0.0014 0.0024	0.0055	0.0041	0.0072	0.0072	0.0123	0.0123	0.0095 0.0155	0.0227	0.0195 0.0280	0.0227	0.0195 0.0280
D	♂	11	0.0009	0.0008 0.0012	0.0023	0.0018 0.0028	0.0059	0.0050	0.0068	0.0068	0.0136	0.0136	0.0111 0.0162	0.0261	0.0219 0.0305	0.0261	0.0219 0.0305
A	♀	9	0.0011	0.0007 0.0012	0.0027	0.0022 0.0040	0.0068	0.0052	0.0083	0.0083	0.0173	0.0173	0.0135 0.0214	0.0375	0.0308 0.0470	0.0375	0.0308 0.0470
B	♀	1	0.0010	0.0010 0.0010	0.0030	0.0030 0.0030	0.0092	0.0092	0.0092	0.0092	0.0231	0.0231	0.0231 0.0231	0.0477	0.0477 0.0477	0.0477	0.0477 0.0477
C	♀	2	0.0009	0.0008 0.0010	0.0023	0.0023 0.0023	0.0070	0.0063	0.0077	0.0077	0.0175	0.0175	0.0165 0.0184	0.0368	0.0334 0.0402	0.0368	0.0334 0.0402
D	♀	4	0.0010	0.0008 0.0011	0.0021	0.0017 0.0023	0.0064	0.0061	0.0067	0.0067	0.0161	0.0161	0.0129 0.0184	0.0337	0.0255 0.0378	0.0337	0.0255 0.0378

EXPLANATION OF DIETS: A, maximum *Drosophila* in all instars; B, maximum *Drosophila* in first three instars, and maximum *Drosophila* alternated daily with maximum *Musca* in instars four and five; C, maximum miscellaneous insects from fields in all instars; D, maximum *Drosophila* in first three instars, and maximum *Musca* in instars four and five.

TABLE II  
WEIGHTS OF ADULT *Phymata*

Diets	Sex	Number Weighed	Average Life in Days	AVERAGE WEIGHT IN GRAMS		Percent Change, First to Last Day	AVERAGE WEIGHTS IN GRAMS			Percent Change, First 10 to Last 10 Days	Average Number of Eggs Produced
				First Day	Last Day		First 10 Days	Middle 10 Days	Last 10 Days		
A	♂	2	63	0.0216	0.0243	12.5 gain	0.0236	0.0247	0.0236	0.0000	.....
B	♂	4	112	0.0228	0.0253	10.9 gain	0.0272	0.0266	0.0261	4.04 loss	.....
C	♂	3	107	0.0215	0.0237	10.2 gain	0.0251	0.0250	0.0238	5.18 loss	.....
D	♂	4	111	0.0294	0.0298	1.36 loss	0.0325	0.0302	0.0308	5.23 loss	.....
A	♀	8	58	0.0350	0.0426	21.7 gain	0.0383	0.0478	0.0457	19.3 gain	3.9
B	♀	1	78	0.0467	0.0756	61.7 gain	0.0607	0.0815	0.0801	40.0 gain	59.0
C	♀	2	97	0.0346	0.0569	65.0 gain	0.0459	0.0588	0.0589	28.3 gain	178.0
D	♀	1	142	0.0354	0.0577	63.0 gain	0.0522	0.0590	0.0612	17.2 gain	275.0

EXPLANATION OF DIETS: A, maximum *Drosophila* daily; B, maximum *Drosophila* and *Musca* on alternate days; C, maximum miscellaneous field insects daily; D, maximum *Musca* daily.



inception of the decline in weight. It occupies approximately three-fourths of the time of the whole instar.

The molting phase of the instar begins where feeding and increase in weight cease. Ideally the curve for this phase should invariably

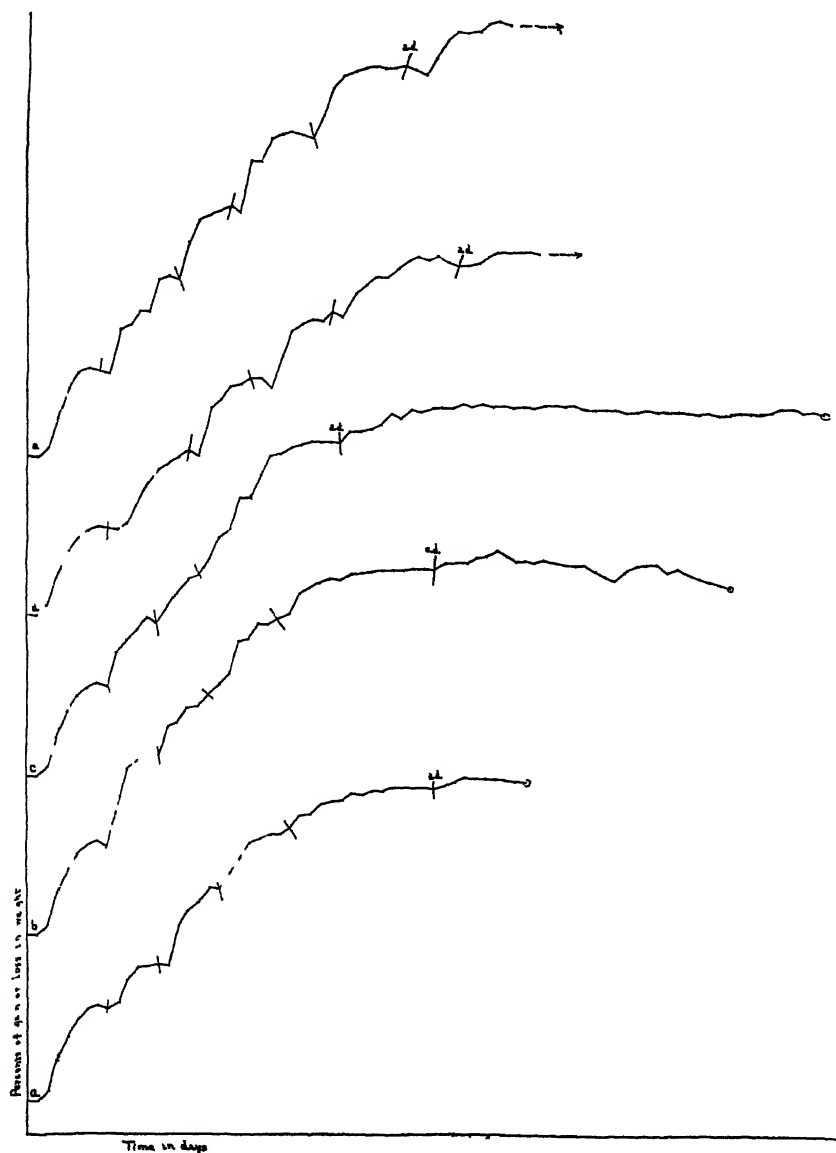


FIG. 1, a, b, c, d.

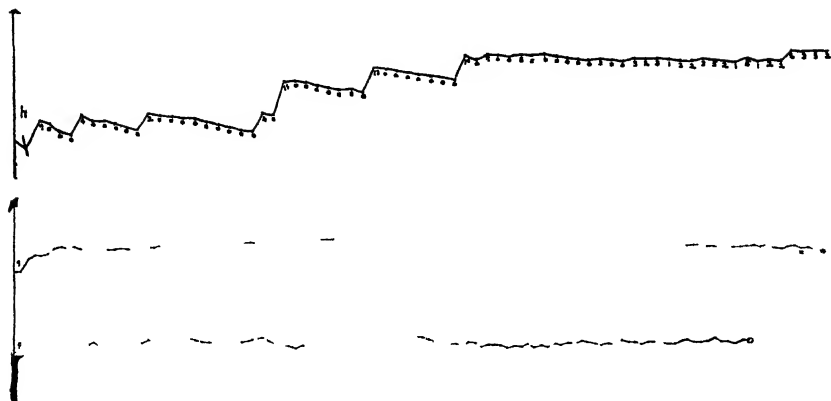


FIG. 1. Weight patterns of *Phymata* maintained on two different diets.

- a. Male. Diet A.
- b. Female. Diet A.
- c. Female. Diet D.
- d. Male. Nymphal life only. Diet D.
- e. Female. Nymphal life only. Diet D.
- f. Male. Adult life of nymph d. Diet D.
- g. Female. Adult life of nymph e. Diet D.
- h. Fifth instar nymph on manipulated diet of *Drosophila*.

NOTE: The transverse lines on the curves mark the limits of the instars. The letter *e* on curve *g* indicates eggs were laid; *ad* signifies adult stage begins; the circles at the end of the curves indicate death of the bug, and the arrows terminating curves *d* and *e* indicate that the adult life of these individuals is represented on curves *f* and *g* respectively. Note that the first 8 and 10 adult days are duplicated on *e* and *g*, and *f* and *h*, respectively. The figures at the daily dots of curve *h* state the number of *Drosophila* sucked out.

show a slight decline for the time preceding the molt because failure to feed results in a drop in weight. Next, the nymph suffers a sharp slump in weight due to the shedding of the old cuticle and the attached parts and a high rate of evaporation from the new soft moist cuticle. No food can be taken at this time, presumably because the skeleton and its internal continuations, as tracheal and gut linings and the feeding stylets, remain soft. Presumably molting also temporarily inhibits the usual functions of other physiological mechanisms. When the newly formed chitinous parts become set, feeding is resumed, this beginning usually in somewhat less to more than 24 hours after the molt.

The maximum losses in weight incident to the molting phase sustained in the 4-5 ecdysis were 0.0017 gram, and those of the 5-adult molt 0.0029 gram. The average weight of 26 dry exuviae from both sexes in the 4-5 molt was 0.000238 gram, and that of 22 from the 5-adult molt 0.000543 gram. On the basis of these data, the dry exuviae represent 14 percent of the loss in the 4-5 molt and 19 percent in the 5-adult molt. Accordingly, the remaining 86 and 81 percents, respectively, are traceable to evaporation, largely from the soft moist new cuticle and but little during the pre-molt part of the phase. In as much as these percents are based on small samples that take no account of sexual differences, they are to be accepted as indicative only.

The slender S-form of the instar curve is therefore explained (1) by extensive rise in weight that results from heavy to light feeding during the first three-fourths of the feeding-growing phase and (2) by the subsequent loss of 10 to 12 percent of the body weight incident to the molting phase. Since the loss in any one instar is offset strongly by the gains, the curve of growth makes a steep net rise during the nymphal stage as a whole.

*Weight Pattern of the Adult.*—Curves *f* and *g*, figure 1, represent respectively a male that lived 111 days and a female that lived 122 days. These are comparatively long lifetimes for reared *Phymata*. The female produced 275 eggs, which number approaches the average obtained in my previous life history work (1941). For these reasons, this pair may be regarded as exhibiting most nearly the features characteristic of the weight pattern of this species. Again, as in *Sinea*, this pattern consists essentially of three phases. The first extends through the one or more days following the 5-adult molt, when the still soft moist adult loses considerable weight from evaporation and failure to feed. This is the molting phase. The second phase begins when the new structures harden and the adult begins to feed. It occupies several successive days, during which the weight climbs from the previous low to the high level that persists throughout the rest of adulthood. This phase is characterized by its limited duration, the sharp and extensive rise in weight and the most prolonged intensive feeding the adult engages in. It may perhaps be called the transition phase. The intense feeding is probably actuated by the semidessicated state of the inner body that resulted from the recent molt. During this phase the adult appears to store the reserve nutrients essential to the genesis of the first sperms and eggs. The third phase consumes the largest part of the time and energy of the adult life, and may be described as the feeding-producing phase. Two other prominent features of this period are the approximately horizontal direction assumed by the curve, and the somewhat periodic drops and rises in weight, which, however, do not depart far from the horizontal mean. The variations in the female weights are sharper and more regularly spaced than in the male, and are brought about chiefly by the functions of feeding, defecation and oviposition. The deposition of the eggs in mass form, rather than singly, contributes significantly to the sharpness of the variations; the sharpness is due not only to the drops resulting from discharge of the masses, but perhaps also to the equally sharp and prompt increases in feeding that follows oviposition. The pattern suggests that the build-up from feeding and oögenesis alternates with loss from oviposition and elimination of feces, or that the accumulation of the maturing eggs in the ovarian tubes temporarily inhibits feeding. This inhibition might be implemented by depression of the alimentary tract by the egg mass whereby the storage capacity of the tract might be reduced. The hungry state brought about thus may then stimulate the short period of intense feeding that follows oviposition. This theory was not tested by dissections of gravid females.

It is of interest too that the larger masses of eggs were yielded in the first half of life, and mostly at intervals of four or five days. By contrast, smaller masses were laid at longer and less regular intervals during the third quarter, and deposition virtually ceased in the last

fourth. The presence of 36 mature eggs in the tubes of the dead bug indicates that oögenesis continued to some extent to the very end of life. This mass of retained eggs obviously served materially to keep the weight at a uniformly high level to the end, and possibly inhibited feeding to a degree that contributed to death.

The rises and drops in the weight of the male are less regular and sharp than in the female, and they tend to flatten out after mid-life as in the case of the female.

Finally it may be noted that the adult life of the bugs represented on curves *a*, *b* and *c* differ from *f* and *g* chiefly in being shorter, and that of the males in particular varied less in the vertical dimension in accordance with their comparatively little sexual performance. These graphed examples are more or less typical of the other weight histories obtained.

*Weight Pattern of a Nymph on Manipulated Diet.*—One nymph of a series scheduled to receive a minimum diet of *Drosophila* chanced to be provided that particular amount of food which produced an extraordinary attenuation of the fifth instar. Whereas the nymphs of *Phymata* ordinarily spend 12 to 15 days in this instar, the above individual remained in that stage for 71 days and was still vigorous when it was deliberately cyanided. In the course of its life in this instar, the bug increased from 0.0060 gram on the first post-molt day to 0.0222 gram on the 70th day. *Drosophila* were supplied at irregular times and in irregular numbers, as I have indicated beneath the day dots on curve *h*, figure 1.

*Rate of Progression in Nymphal Growth.*—The growth quotient, adopted here as a means of expressing the rate of progress in nymphal growth, is explained in my article on *Sinea*. The pertinent data for all individuals that lived to the adult stage are given in Table III. These are stated as averages and extremes for each instar and for the nymphal stage as a whole, and are classified according to diet and sex. Also the weights of the exuviae, presented in Table IV, bear on the rate of progression.

On the whole, the pattern of progression in *Phymata* is essentially like that of *Sinea*. The chief features follow. First, the growth quotient for the first instar tends to be greater than the quotients of instars two to five, despite the assumption of 0.0003 gram, which will probably prove too high; and this difference is more pronounced in the females. Second, the lower quotients of fifth instar males indicate that diets A, B and C were inadequate, probably through the inaptitude of these larger nymphs in securing small prey, i.e., *Drosophila*. Compared with the females, these lower quotients reflect also the greater avidity with which the females feed even before they become adults. Third, the quotients for any one instar, sex and diet exhibit a wide range, thus emphasizing the extensive individual variation of which the species is capable. Fourth, most of the average quotients exceed 2.0, hence do not conform closely to Przibram's principle of doubling, but vary from 1.9 to 3.9. The growth rates indicated by the weights of the exuviae (Table IV) are more nearly uniform than those of the whole insects. This may be due in part to the inclusion of the exuviae of well-fed nymphs only, whereas whole nymphs provisioned at varied dietary rates figure in the calculations in Table III.

TABLE III  
GROWTH QUOTIENTS OF *Phymata*\*

Diets	Sex	Nymphs Weighed	AVERAGE AND EXTREME GROWTH QUOTIENTS					
			First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage
A	♂	7	3.2 1.7-4.7	2.3 1.8-3.6	2.4 1.8-3.2	2.3 2.1-2.6	1.8 1.6-2.0	80.0 64.0-92.0
B	♂	4	2.6 2.3-3.0	2.6 2.0-3.3	2.5 2.1-3.0	2.6 2.5-2.7	1.9 1.5-2.2	82.0 76.0-88.0
C	♂	3	2.6 2.3-2.7	2.5 2.2-2.8	2.7 2.4-2.9	2.1 1.8-2.6	1.8 1.6-2.1	76.0 65.0-87.0
D	♂	4	2.9 2.3-3.7	3.1 2.6-3.1	2.6 2.3-3.1	2.5 2.4-2.7	2.2 2.1-2.4	94.0 87.0-102.0
A	♀	9	3.5 2.3-5.3	2.7 2.0-3.8	2.3 1.7-3.1	2.5 2.2-3.2	2.1 2.0-2.4	125.0 103.0-157.0
B	♀	1	3.3 .....	2.3 .....	3.5 .....	2.8 .....	2.2 .....	159.0 .....
C	♀	2	3.9 3.7-4.0	2.2 1.7-2.6	2.0 1.8-2.3	2.6 2.4-2.8	2.2 2.1-2.3	122.0 111.0-134.0
D	♀	1	3.0 .....	3.3 .....	1.7 .....	2.5 .....	2.6 .....	124.0 .....

\*For explanation of diets, see legend, Table I.

TABLE IV  
WEIGHTS OF EXUVIAE. WELL-FED *Phymata*

Exuviae from Molt Number	Number of Exuviae Weighed	Total Weight of Exuviae in Grams	Average Weight of Single Exuviae	Growth Quotient
1-2.....	35	0.00087	0.0000248	...
2-3.....	35	0.00145	0.0000414	1.7
3-4.....	29	0.00290	0.0001000	2.4
4-5.....	26	0.00620	0.0002380	2.4
5-adult.....	22	0.01195	0.0005430	2.3

The rate of progression may be expressed also in terms of the net weights gained in the several instars. The net gain is the value secured by subtracting the first day weight from the last day weight of each instar. The sum of the five net weights constitutes the total net gain made during the entire nymphal or growth life of the bug. This sum was then employed as the base figure in determining the amount of

weight, in percents, contributed to the nymphal total in each of the instars. If the rate of progression followed closely the Przibram doubling principle, the net weights gained in the five instars would be 3.125, 6.25, 12.50, 25.00 and 50.00 percents, respectively. Reference to my data for 34 nymphs in Table V will show that the pattern of progression only approximates the ideal one given above. They indicate further that fifth instar males on diets A, B and C contribute less to the total net gain of the whole nymphal stage than the better fed individuals of diet D or the more avid females of the same instar.

Departures from the ideal proportions may be attributed to failure to take the weights at precisely the lowest point, at the beginning, and

TABLE V  
INSTAR CONTRIBUTIONS TO TOTAL NET WEIGHT OF NYMPHS, IN PERCENTS

Diet	Sex	Number Weighed	AVERAGE AND EXTREME PERCENTS, BY INSTARS				
			First	Second	Third	Fourth	Fifth
A	♂	6	2.7 1.4-3.5	4.5 3.5-6.2	13.7 10.2-18.5	32.38 26.25-35.00	46.17 40.00-55.88
B	♂	4	2.6 2.2-3.0	6.0 4.8-7.8	10.6 8.4-17.4	33.21 27.20-40.09	45.16 35.21-52.07
C	♂	2	2.8 2.3-3.2	6.3 5.5-7.0	17.8 17.7-17.9	30.2 28.0-32.4	42.94 41.79-44.09
D	♂	10	2.8 1.7-4.4	4.97 3.8-9.0	13.36 10.3-15.1	28.14 20.3-34.0	50.97 47.30-54.24
A	♀	6	1.9 1.5-2.4	4.4 3.6-5.1	11.75 9.6-13.2	29.24 26.63-32.00	53.12 50.00-57.91
B	♀	1	1.6 .....	3.5 .....	13.4 .....	29.5 .....	52.03 .....
C	♀	1	2.6 .....	4.1 .....	9.7 .....	31.02 .....	52.59 .....
D	♀	4	1.9 1.8-2.0	3.6 3.1-4.3	11.2 7.1-17.4	28.75 24.50-33.70	54.57 50.00-62.26

the highest point, at the termination of the instar; to irregular progression; to the possibility that some individuals may feed sparingly in one instar, then feed more heavily, or "catch up," in the next. On the other hand, these departures may be natural and normal to the species. visioning; to hereditary differences between the individuals, and to

#### DISCUSSIONS

*Periodic Weights.*—Since the purpose of weights is to secure a complete and correct picture of the changes in bulk, and to measure the amount of the changes occasioned by the several contributory

factors, it must be apparent that only continuous second by second records can approach achieving these objectives. For instance, securing the correct growth quotients depends on getting the lowest post-molt weight and the highest pre-molt weight of each instar. Periodic weights reflect only the status of the organism at the times of weighing. As a consequence, the investigator is obliged to make assumptions regarding the nature and extent of the intervening events or to disregard the problems involved. By the periodic method, correct data are obtained now and then but only by the chance that the experimental organism be weighed at the critical moment, with the result that most records taken involve some degree of error. Yet daily weights come nearer reflecting the nature of the vital phenomena than do weights taken at longer intervals.

Despite the desirability of continuous weight records, it seems improbable that man can devise a machine automatically capable of isolating and recording the amount of the gains and losses due to such physiological functions as reproduction, digestion, respiration and molting.

*Comparison of Sinea and Phymata as Experimental Bugs.*—Despite efforts made to provide the amount of *Drosophila* and *Musca* requisite for the maximum biological performance of *Sinea*, this objective was probably realized but rarely. By contrast, the best-fed *Phymata* at least approached that goal more closely. The reasons for this difference in performance are fairly obvious, since they occur in the relative adaptiveness of the two forms for predation. The fourth and fifth instar nymphs and the adults of *Sinea* bear long spiny forelegs which are comparatively inept in the capture of flies so small as *Drosophila*, and, on the other hand, these forms definitely evade the onrushing boisterous *Musca*. The curves for these instars are therefore less steep than those for instars one to three, which fact suggests the need for a third prey species between *Drosophila* and *Musca* in size. The corresponding nymphs of *Phymata* capture both flies with relative facility and do not require an intermediate species of prey to perform well in captivity. *Sinea* possesses the advantage that it feeds on flies newly inactivated with cyanide, but seems to accept them only when inordinately hungry, hence fails to achieve its best performance on this fare. *Phymata* makes the grasping response only when stimulated by moving objects.

#### SUMMARY

Series of *Sinea diadema* and *Phymata pennsylvanica americana* were caged and fed individually under controlled conditions and differentiated fares from hatching to death of the adult. Daily individual weights provided data pertinent to the following aspects of life:

1. Average and extreme weights that show the variability in bodily bulk of both nymphs and adults;
2. The pattern of normal rises and drops in weight, which indicate the nymphal stage consists of a feeding phase and a molting phase, while the adult life embraces three somewhat distinct phases;

3. The relative amounts of weight changes occasioned by various factors, but ingestion and molting in particular;

4. Daily losses sustained by a series of adult male *Sinea* deprived of food, and the weight history of a fifth instar *Phymata* which was fed a minimum diet and lived 71 days, when it was killed;

5. Growth quotients, which bear on the rate of increase or progression in weight from instar to instar, and indicate that these bugs only roughly approximate the principle of doubling stated by Przibram and Megusar;

6. The amount, in percents, of weight contributed by each of the five instars to the total net nymphal gain; this is another method of expressing the progression principle;

7. The limitations of periodic weights indicate the desirability of improved weighing methods that will reveal more precisely the characteristic features of the entire weight picture;

8. Relative merits and shortcomings of *Sinea* and *Phymata* as laboratory species for weights studies.

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## THE WEIGHTS OF *SINEA DIADEMA* (FABR.) (Reduviidae, Hemiptera)<sup>1</sup>

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The changes in volume sustained by insects during their post-embryonic life have been investigated in three ways: by calculating the amount of water displaced by submerged specimens (Yagi), by measuring the dimensions of the whole or parts of the body, and by weighing the exuviae and/or the entire organism. The scientific results obtained by these techniques have already been adequately reviewed by Abercrombie, Bodenheimer (1932, 1933), Calvert, Harries and Henderson, Hodge, Lincoln, Ludwig and Yagi.

In the present study of the weight pattern of the common assassin bug, *Sinea diadema*, at Urbana, Illinois, five lots of individuals were reared during 1942 to 1944. Each bug was caged and fed individually, and kept at 80° Fahrenheit and a relative humidity of about 80 per cent. Differential feeding was employed in order to learn its effects on the growth-weight pattern of the bugs. The experimental individuals may be regarded as constituting the following three classes when separated according to the approximate amount of adult *Drosophila melanogaster* Meig. and *Musca domestica* L. allowed in the diet of the nymphs and adults: (1) bugs allowed enough *Drosophila* to bring them hardly to the adult state (diet X); (2) bugs given all the *Drosophila* both nymphs and adults were able to utilize (diet A), and (3) bugs supplied all the *Drosophila* they could use as nymphs, and all the *Musca* the adults were able to use (diet D). The bugs failed to achieve their maximum biological performance even on the most adequate diet D.

While all individuals concerned here were weighed daily, complete records, from hatching to death, were not taken on all of them. Some of the series were weighed throughout the postembryonic life, others only during the nymphal stage or in the fourth and fifth instars, and still others only as adults. This report is based on such more or less complete weight histories of 195 individuals. All weights were taken on a Chainomatic balance sensitive to one ten-thousandth gram. The curves (fig. 1, a-g) are based upon the percent of loss and gain sustained by the insect from day to day, and not on the absolute changes reflected by the daily weight records.

### RESULTS

*Range in Weights of Nymphs.*—Like all heterometabolous insects, *diadema* undergoes a large increase in bulk in the course of development. The question, "How much does the bug weigh?" is therefore

<sup>1</sup>Contribution No. 275 from the entomological laboratories of the University of Illinois. This investigation was financed by the Graduate School of the University.

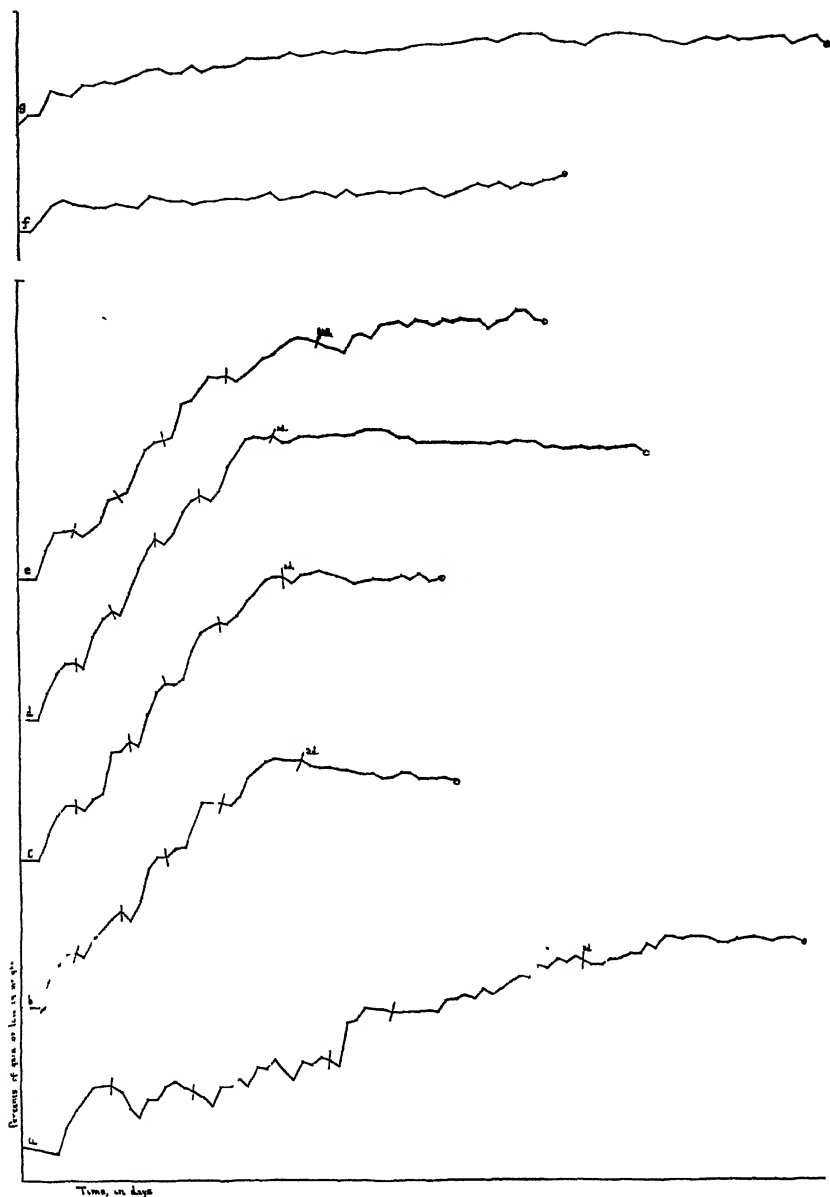


FIG. 1. Weight patterns of *Sinea* maintained on three different diets.

a. Male. Diet X.

b. Male. Diet A.

c. Male. Diet A.

d. Female. Diet A.

e. Female. Diet D.

f. Male adult. Diet D.

g. Female adult. Diet D.

NOTE: The transverse lines on the curves mark the limits of the instars; *ad* stands for adult, and the circles at the end of the curves indicate death of the bug. Curves *a* to *e* represent both nymphal and adult life; curves *f* and *g* only adult life.

TABLE I  
RELATION OF DIET TO WEIGHT OF ADULT *Sinea*

Diet	Sex	Number of Adults Weighed	Average Life in Days	AVERAGE WEIGHT IN GRAMS		Percent Change First to Last Day	AVERAGE WEIGHTS IN GRAMS			Percent Change First 10 to Last 10 Days
				First Day	Last Day		First 10 Days	Middle 10 Days	Last 10 Days	
X	♂	10	7.5	0.0163	0.0147	9.8 loss	.....	.....	.....	.....
A	♂	13	42	0.0299	0.0228	23.7 loss	0.0309	0.0300	0.0283	8.4 loss
D	♂	16	56	0.0298	0.0353	18.6 gain	0.0295	0.0300	0.0310	5.1 gain
X	♀	All female	bugs on this	diet died as	nymphs.	Underfed.	0.0409	0.0380	0.0344	15.9 loss
A	♀	7	31.4	0.0388	0.0324	16.5 loss	0.0433	0.0484	0.0344	15.26 gain
D	♀	16	57.5	0.0370	0.0518	28.6 gain			0.0511	

answerable by a series of numbers that express the amount and direction of the changes from day to day and stage to stage. Moreover, individuals of a series do not produce identical weight records during their growth, for significant variations associated with sex, amount of food taken, and possibly heredity, occur constantly. The single value 0.00027 gram is employed here for the weight of the newly-hatched unfed nymphs. This number represents the average obtained from weighing 62 individuals collectively. Progress in the weight of the nymphs, and an indication of the inter-individual variations in weight traceable to differences in sex, food and possibly heredity, are expressed by the following records for a series of 45 nymphs on diets X, A and D. The mature, about-to-molt nymphs of the first instar varied in weight from 0.0006 to 0.0014 gram; those of the second from 0.0010 to 0.0030; third instar, 0.0017 to 0.0077; fourth, 0.0044 to 0.0188, and the fifth, 0.0093 to 0.0462 gram. In most instances, the lowest weights cited for each instar pertain to low-fed (diet X) male nymphs, the highest to well-fed (diet D) female nymphs. The range in net gains, by instars, was: 0.0004 to 0.0012 gram; second, 0.0003 to 0.0020; third, 0.0009 to 0.0050; fourth, 0.0012 to 0.0125, and fifth instar, 0.0023 to 0.0286. For the nymphal stage as a whole, the variation in net gain was 0.0066 to 0.0460 gram.

Even the 14 individuals composing the best-fed series (diet D) displayed a wide range in amount of gain in weight. For the entire growth stage, they multiplied their weights by 107 to 170 times. The eight included males varied from 110 to 141 times, the six females from 109 to 170 times. In terms of per cents, the spread for the males was 10937 to 13974, while that for the females was 10826 to 17011, or an average increase of 13356 per cent from hatching to maturity for the 14 nymphs.

*Range in Weights of Adults.*—The capacity for variation in the adults is not so extreme as that of the nymphs. The newly transformed adult is decidedly lighter than the full grown, about-to-molt nymph, on account of the loss in solids and fluids suffered during the last molting process. The amount of gain made varies thereafter largely with sex and the bulk of food ingested (Table I). Individuals fed meagerly as nymphs and adults live only a few days at most, feed subnormally even when adequate food is provided, lose weight from day to day and produce no eggs. On the other hand, individuals allowed a more or less adequate quantity of prey in both stages add weight rapidly after the final molt. From Table I it may be seen that medium-fed bugs (diet A) reach their peak weights, i.e., the highest weight or weights reached during adult life, early in the stage, but lose gradually thereafter so that their weight on the final day, or in the last 10 days, falls below that of the first day or first 10-day period. Associated with this pattern is failure to produce eggs or ability to produce but few, and a comparatively brief adulthood. But well-fed adults (diet D) given *Musca* commensurate with their ability to utilize them, attain their peak weights late in life, and generally in the last 10-day period, if not on the last day. Moreover, the females produce a fair number of normal eggs deposited naturally in two rows, persist in oviposition late into life, and live a relatively long time. It may therefore be

stated as a rule that adult *diadema* achieve their peak weights later and later in life as the amount of food ration is increased.

The greatest weight attained by any individual reared in the course of this study was 0.0733 gram, an adult female late in her lifetime.

*Weight Pattern of the Nymph.*—The developmental curve for medium (diet A) and best-fed (diet D) nymphs (fig. 1, b-e) consists of five similar attenuated S-shaped figures, which correspond to the number of instars and molts. The curve of each instar comprises two phases distinguishable by certain physiological characteristics. The first phase occupies most of the time of the instar, and begins one to two days after exuviation. The new cuticle has been formed and set, the mouth-parts hardened, and the bug resumes feeding. The rate of ingestion is surprisingly high in the first one to several days, but then falls off somewhat gradually until it becomes negligible and probably ceases for one to several hours just previous to the next molt as the body tissues become saturated with food and/or unexcreted waste. Paralleling the changes in rate of feeding, the body weight ascends abruptly for one to three days, after which the rate of acceleration declines with the approach of saturation. Since this aspect of the instar is characterized by heavy feeding and a corresponding growth, it may be designated the *feeding-growing phase*.

The second phase begins some hours to a day or two before the molt, and ends one or two days after the molt with the resumption of feeding. Little if any feeding takes place just before the molt, hence no growth occurs, and some records indicate a slight pre-molt decline in weight. Then follows the shedding of the cuticle, which process is accompanied by evaporation of fluid from the new cuticle while this remains soft and moist, and probably also by partial dessication of the viscera, which stimulates the intensive feeding observed early in the feeding-growing phase. The second phase ends with the hardening of the chitinous parts, including the stylets, and restoration of the ability to feed. Due to cessation of feeding and to exuviation and evaporation, the body weight declines markedly, but the loss sustained in this phase is less than the gain in the feeding-growing phase, with the result that a pronounced net increase in weight accumulates during the succession of instars. The second phase requires one to three days, its duration varying more or less with the several instars and feeding. The actual process of exuviation, however, requires less than an hour, and lasted only 15 minutes in a few observed instances. This aspect of the instar may be termed the *molting phase*.

While the above characteristics apply to all the five instars of *diadema*, they must be qualified with reference to the first instar. The nymph has been observed to refuse food and to gain no weight during the first and even the second day after hatching. Dissections revealed that the stomach contains a whitish granular substance comparable to the nutrient present in the egg during the early embryonic phase. The substance in the gut quite clearly originates in the egg, and apparently serves to nourish the nymph in its first days. Since it ingests nothing while consuming energy in activity, the nymph loses weight until feeding on *Drosophila* commences. This loss, whose amount is

not yet accurately determined, is represented on curves *b* to *e* by a slight decline.

*Weight Pattern of the Adult.*—The weight picture of the adult may be regarded as composed of three phases (fig. 1, *b* to *g*). The first is characterized by a decided loss in weight during the first one or two days following the 5-adult molt. The loss results from exuviation and from evaporation of fluids from the soft new cuticle of the newly-molted adult, these being the same factors that operate in the declines which follow the nymphal molts described above.

The second phase is distinguished in best-fed (diet D) adults by a sharp and pronounced rise in weight extending through the first one to several days of adulthood. This increase generally not only offsets the loss incurred in the molting phase but indicates a reserve that implements the inception of the third phase. As in nymphal instars one to five, this increase in the second phase results from more or less intensive feeding which appears to be actuated by the presumed desiccated state of the body, a condition growing out of exuviation and the simultaneous loss of surfacial moisture. The adult usually ingests as much food in this as in any other period of comparable length, and if strong enough to feed at all, it does so during this phase.

The third phase of the weight pattern embraces all the rest of the time span of adulthood. Even a quick glance at curves *b* to *g* will show it is characterized by frequent deviations from the horizontal due to the normal intakes and eliminations of materials incident to feeding, defecation, respiration and reproduction. However, these fluctuations are of a minor amount and an irregular nature compared with the pronounced and rhythmical rises and drops of the S-shaped nymphal curves. Moreover, the deviations are more extensive in the females because of their greater capacity or disposition to feed and the larger bulk of the sexual products. But when we take an over-all view of adulthood, the third phase proves to be a somewhat flat horizontal plane, signifying that the losses are fairly well offset by the gains, and suggesting that extreme departures from the horizontal, either upward or downward, are made impossible by the physical and physiological limitations that characterize the species.

*Amount of Changes in Weight.*—The character of the gains and losses incident to nymphal growth in the molting and feeding-growing phases was described above in general terms. Daily weight records now permit a restatement of certain of these changes in more precise mathematical language. First, I cite records for a series of four male and four female nymphs, reared on the best diet (A), to indicate the percentage of daily increase in the feeding-growing phase of the instar. Only the third, fourth and fifth instars are presented. The numbers express the lowest and the highest, or extreme gains in terms of percents, and the average percents.

On the first day of the third instar, the gains in weight among the eight nymphs were: extremes, 13.0 and 60.8 percent, average 46.0 percent. The corresponding values for the second day: extremes, 25.6 and 65.4, average 45.8; third day, extremes, 15.5 and 28.8, average 18.6. Four of the nymphs continued to gain, adding 5.5 to 12.5 percent

in the one or two days remaining before the molt, while the other four lost 1.6 to 4.1 percent in that period.

Corresponding data for the fourth and fifth instars follow. *Fourth instar*: first day, extremes, 1.6 and 61.4, average 26.0; second day, extremes 4.3 and 57.3, average 36.3; third day, extremes 9.6 and 44.6, average 27.5; fourth day, extremes were -0.8 and +36.5, average 11.8. Changes in the remaining one or two days of the instar ranged from +5.5 to -10.3 percent. *Fifth instar*: first day, extremes 2.9 and 17.3, average 11.3; second day, extremes 11.7 and 43.6, average 27.8; third day, extremes 10.6 and 36.8, average 21.0; fourth day, extremes 5.9 and 27.2, average 18.2; fifth day, extremes 3.5 and 18.3, average 11.2; sixth day, extremes -2.5 and +12.4, average +3.2; seventh day, extremes -8.2 and +5.0, average +0.44. Changes in the remaining one to three days of the instar average -3.6 percent.

A few comments on the above records are desirable. First, the data for any one day are not strictly comparable among the eight bugs because of the variation in duration of any one instar from one individual to another. Second, the average rate of daily increase in weight is highest early in the instar, and declines thereafter to the end of this growth period. In many cases, the nymphs sustained significant losses in the last one or two days preceding the molt. Besides, were the weights taken hourly or at shorter intervals, instead of daily, every individual would probably be found to suffer such a pre-molt loss in each instar, and, moreover, spread in extreme weights would be considerably reduced. Third, the average increase in the fifth instar falls below that of the previous four, probably because these larger nymphs are relatively inept in capturing the *Drosophila* on account of its small size, and also seem to be "frightened" by the *Musca*. As a consequence, this instar is probably prolonged beyond its natural duration and rarely attains its maximum weight on diets provided.

Next are considered the amounts of loss and gain peculiar to the molting phase of the instar. Three factors were considered as possibly responsible for these changes, defecation, exuviation and evaporation. Defecation was eliminated as a possibility when the use of white blotters in the cages, and inspection of the exuviae, showed that no feces are discharged during the molting phase. The weight of the exuviae, subtracted from the total loss during the phase, yields the approximate amount of loss due to evaporation, largely from the soft moist newly-forming cuticle. The weights cited below were taken from fifth instar nymphs at the time of their transformation to adults, and only the individuals displaying the more extreme losses are included because I consider it probable that only these indicate the actual total decline suffered in the molting phase.

The average loss based on a series of such records was 0.0041 gram. The dry exuviae from 70 males averaged 0.00081 gram, and those of 62 females averaged 0.00094 gram, per bug, the average for both sexes being 0.00087. The exuviae alone therefore account for only about one-fifth, or 21 percent of the total loss sustained in the phase, while the remaining four-fifths, or 79 percent, appear to arise from evaporation of fluids largely in the interval between shedding of the old cuticle and the hardening of the new one. In addition to these post-molt

losses due to exuviation and evaporation, the nymph also loses a noteworthy amount of weight in the one or two pre-molt days when it takes no food. This loss is estimated at one or two percent, so that the sum of all the losses experienced in the molting phase is approximately 14 percent of the total body weight as of the end of the feeding-growing phase of the instar. Moreover, there seems no good reason to doubt that nymphs in the molting phases of the preceding four instars sustain approximately the same percentage of loss, for molting in every instar involves a day or more of interruption in feeding, exuviation and rapid surfacial evaporation. That the loss in weight is in proportion to the size of the molting bug is indicated by the fact that the weights of the whole body and of the exuviae in the successive instars multiply at approximately the same rate. See Rate of Progression, below.

TABLE II  
LOSSES IN WEIGHT INCIDENT TO COMPLETE STARVATION

Bug	Days Adult was Fed	Last Weight Before Starvation	Weight of Dead Bug	Days Bug Lived	Total Loss in Percents	Average of Daily Losses in Percents
1	0	.0358 gr.	.0256 gr.	14	28.7	2.31
2	0	.0300	.0232	8	22.7	2.86
3	0	.0238	.0207	5	13.0	2.70
4	14	.0313	.0258	6	17.0	3.27
5	21	.0325	.0268	6	17.5	3.15
6	22	.0277	.0254	4	8.3	2.27
7	23	.0337	.0216	8	35.9	5.76

#### LOSS OF WEIGHT IN STARVED BUGS

Curiosity as to the rate at which starved bugs lose weight prompted me to utilize a few opportunities to make observations on this point. Table II gives the chief facts obtained from seven adult males. Males numbered 1 to 3 sustained malformations of the stylets in the 5-adult molt, hence took no food as adults, and the losses in weight are from substance derived entirely by nymphal feeding. Bugs 4 to 7 had functional mouthparts and fed 14 to 23 days as adults before food was withheld. Numbers 1 to 3 survived an average of 9 days and suffered an average total loss of 21.5 percent during those days before they succumbed. By comparison, bugs 3 to 6, fed an average of 19 days before food was withheld, survived an average of only 5.3 days while losing an average of 14.3 percent of their weight. Well-fed male number 7 lived only 8 days, yet sustained the relatively great total loss of 35.9 percent.

#### RATE OF PROGRESSION IN GROWTH

Because the weight of nymphal *diadema* is subject alternately to losses in the molting phase and gains in the feeding-growing phase, the growth of the bug is discontinuous. Then arises the question whether the increase in weight from one instar to the next progresses haphazardly or according to some fixed principle. A definite answer



to this question appears to have been formulated first by Przibram and Megusar from their study of the Egyptian mantid, *Sphodromantis bioculata* Burm. They reported that the nymphal mantid doubled its weight in each instar, thus advancing in a uniform manner to the adult state. Their doubling principle was said by Bodenheimer (1932) to apply also to the preovipositional phase of adulthood in the phasmid, *Carausius morosus* L. Since the work of Przibram and Megusar, published in 1912, several other investigators probed the idea of regular progression in other insects, both Heterometabola and Holometabola. The results are divided with reference to the Przibram principle, some corroborating, others tending to negate it.

My weight studies on *diadema* yielded two bodies of data that pertain to this question, first the weights taken from the living nymphs during their development, and second the weight of exuviae from well-fed

TABLE III  
GROWTH QUOTIENTS OF NYMPHS. SUMMARY

Diet	Sex	Nymphs Weighed	AVERAGE AND EXTREME GROWTH QUOTIENTS					
			First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage
X	male	5	2.74 2.2-3.7	2.05 1.4-2.3	2.05 1.8-2.2	2.2 1.5-2.4	2.18 1.5-2.7	43.86 25.2-55.2
X	female	3	2.87 2.6-3.0	2.2 2.0-2.6	2.23 1.9-2.4	2.47 2.2-2.7	2.37 2.2-2.6	78.27 65.5-101.9
A	male	18	3.54 2.6-4.8	2.48 1.6-3.7	2.67 1.9-3.5	2.48 1.9-2.9	2.26 2.0-2.6	119.4 85.9-144.1
A	female	12	3.6 3.0-5.2	2.47 1.7-3.6	2.57 2.0-3.3	2.56 2.1-3.0	2.52 2.1-2.8	149.3 109.2-170.4

nymphs of the five instars (Tables III and IV). Following the practice of previous students, I have adopted the growth quotient as an expressive means of stating the amount of progress made in the succession of instars, a method first employed by Jucci (Bodenheimer, 1932). This quotient is obtained simply, by dividing the final or end weight of the nymph, either in an instar or the whole nymphal stage, by its initial weight in the same stage.

The 38 nymphs concerned in Table III were fed at two rates, on diets X and A. The 38 individual records are totalled as (1) averages and (2) extremes for each instar and for the whole nymphal stage. The quotients for the whole stage are not equal to the sum of the quotients of the five component instars.

Several general facts may be deduced from these data. First, the bugs within any one sex-diet series exhibit a considerable variation in average and extreme growth quotients from instar to instar. Second, the consistently major difference lies between the first instar, on the

one hand and the second to fifth, on the other. Third, conspicuous advances in growth quotients appear as the ration is increased from low (diet X) to medium or near-maximum (diet A). Fourth, excepting the first instar, the rate of increase in the males on diet X departs but little from the doubling principle of Przibram, but departs considerably from it in the females of the same dietary series, and the degree of divergence reaches its maximum in the better-fed males and females on diet A.

This study, therefore, indicates that the growth quotient varies with both sex and quantity of food allowed the experimental bug, increasing from male to female and as the dietary is improved. So far as the intersexual difference is concerned, this may hinge on the normal greater avidity of the female. The study indicates further that *diadema* at most merely approximates the doubling principle and does so only when fed at a near-minimum rate (X). When allowed a more nearly adequate quantity of food, the weight increase proceeded at a greater rate that transcends doubling, attaining the maximum of about 2.5

TABLE IV  
WEIGHT OF EXUVIAE

Exuviae from Molt Number	Number of Exuviae Weighed	Total Weight of Exuviae in Grams	Average Weight of Single Exuviae	Growth Quotient
1-2.....	46	0.0012	0.0000261	
2-3.....	27	0.0012	0.0000444	1.7
3-4 .....	27	0.0034	0.0001260	2.8
4-5.....	35	0.0106	0.0003029	2.4
5-adult.....	30	0.0232	0.0007733	2 6

among female nymphs. That sex and quantity of food are factors regulating the rate of weight increase is indicated most strikingly by the extreme figures for each instar and by the data cited under "nymphal stage" in Table III.

Also the weights of the exuviae from the five instars (Table IV) indicate the nature of the growth rate. Since the exuviae of only well-fed nymphs are admitted here, these data correspond to the weights of the whole bugs given diet A, Table III. Again, excepting the two-three molt, the rate of progression through the instars, as reflected by the exuviae, is fairly uniform and closely approximates the number 2.5, the quotient derived from the weights of the well-fed nymphs cited in Table III.

#### NOTE

Discussions, summary and references cited for the study of *Sinea* are combined with those pertaining to *Phymata*, and will be found at the end of the previous article on the latter bug.

## SEVEN NEW MITES FROM RATS IN PUERTO RICO

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The new species of mites described in this paper were discovered during surveys of the rats of Puerto Rico. These surveys have as their object the classification of arthropods associated with or parasitic upon rats to the end that possible new vectors of endemic typhus fever may be made known to investigators. Types of these new species are in the entomological collection of the Department of Medical Zoology, School of Tropical Medicine, San Juan, Puerto Rico.

### Family Laelaptidae

#### *Atricholaelaps strandtmanni* n. sp.

##### Figure 2

*Female*.—Body well provided with long setae, about .70 mm. long (exclusive of capitulum) and about .52 mm. wide. Chelicerae large and prominent the movable arm toothed, the fixed arm with a process. Sternal plate sculptured with three pairs of long setae and two pairs of pores placed as usual for the genus, and as in other species it is preceded by a sclerotized pre-sternal area. Posterior to the sternal plate is a pair of minute plates which may be remnants of the metasternal plates, but the metasternal setae are located some distance posterior to them. Endopodal plates well sclerotized. Genitoventral plate large, removed from the anal plate by about the width of the anal pore, posterior portion broader than the anterior, the border of the latter weakly sclerotized; genital setae long and prominent. Metapodal plates three on a side, two small and one large, the largest being about one-third as wide as it is long. Anal plate triangular with the anal pore closer to the anterior border than it is to the posterior. Paired anal setae at a level slightly anterior to the middle of the anal pore; unpaired anal seta located slightly anterior to the posterior edge of the plate. Posterior portion of the ventrum with many setae which form irregular rows; of particular interest is such a row consisting of about ten setae located between the genitoventral and anal plates and their adjoining areas. Peritreme extending to the middle of coxa I, the inner edge very irregular. Stigmal pore distant from the lateral border of the body. Dorsal plate occupying most of the dorsal surface of the body, with many setae. Chaetotaxy of the legs characteristic of the genus.

*Type material*.—Female *holotype* from *Rattus* sp. or *Mus M. musculus* collected at Camp O'Reilly, Gurabo, Puerto Rico, during the period April 17 through October 9, 1945.

*Remarks*.—This new species is similar to *A. megaventralis* Strandtmann in having a dorsal plate which occupies most of the dorsum but differs from the latter in that the anal pore is closer to the anterior

border of the anal plate than it is to the posterior one and in the shape of the largest metapodal plate.

***Borinquolaelaps setulus* n. sp.**

Figure 5

*Female*.—Body sparsely provided with setae, about .38 mm. long (exclusive of capitulum) and about .22 mm. wide. Sternal plate not sculptured, longer than wide with ear-like extensions anteriorly, with the usual number of setae and pores, the former being rather weak. Metasternal plates large but weakly sclerotized the setae located on the outside borders. Endopodal plates very much reduced. Genital plate weakly sclerotized, slightly rotund posteriorly. Ventro-anal plate large, closely approaching the genital, shield-shaped, provided with three pairs of setae in addition to those of the anal pore. The areas lateral to the ventral plates and posterior to the legs bear on each side four setae of which the most posterior is curved and robust, longer than the others. Metapodal plates not discernible. Peritreme long and narrow extending to beyond the anterior margin of Coxa I. Dorsal plate not occupying the entire dorsal surface, sparsely provided with short setae anteriorly, posteriorly with two pairs of much longer curved ones. Chaetotaxy of the legs characteristic of the genus.

*Type material*.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, November 4, 1946.

*Remarks*.—This new species is similar to *B. dentatus* Fox from which it differs particularly in the shape of the ventro-anal plate.

***Blattiosocius keegani* n. sp.**

Figures 6 and 7

*Female*.—Body oval, about .44 mm. long (exclusive of capitulum) and about .22 mm. wide. Chelicerae large (fig. 6), fixed arm without a process bearing three teeth, much shorter than the movable arm which is armed with one tooth. Sternal plate as in fig. 7, its setae weak. Metasternal plates absent, but the setae present. Entopodal plates absent. Genital plate with the anterior border rounded, the posterior one truncate; genital setae located at the lateral edges. Ventro-anal plate large, shield-shaped, bearing three pairs of setae in addition to those of the anal pore. Paired anal setae level with the posterior border of the anal pore; unpaired anal seta of the same size as the paired ones located near the posterior border of the plate. Metapodal plates absent. Flanking the genital and ventro-anal plates are four setae on a side of which the most posterior are large and curved. Peritreme very short reaching to about the middle of Coxa III, the stigma distant from the lateral border of the body. Dorsal plate not covering the entire dorsal surface, armed with long setae. Legs armed with weak setae.

*Type material*.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, April 15, 1947, and female *paratype* from same host and locality, June 25, 1946.

*Remarks*.—This new species is similar to *B. triodons* Keegan from which it differs in details of the shape of the ventral plates and in the armature of the chelicerae.

## Family Ascaidae

*Asca muricata* n. sp.

## Figure 1

*Female*.—Body provided with setae of moderate length, about .32 mm. long (exclusive of capitulum) and about .17 mm. wide. Chelicerae large, toothed. Sternal plate very weakly sclerotized, its setae short. Anterior pair of sternal setae inserted near the anterior border far above the pores; most posterior pair of sternal setae located far below the posterior pores. Metasternal setae inconspicuous, their plates apparently absent. Endopodal plates much reduced or absent. Genital plate weakly sclerotized, the setae short. Between the genital plate and the ventro-anal plate are six setae arranged in two rows, one consisting of four setae and the other of two. Ventro-anal plate broader than long, armed with several setae in addition to the anal ones. Metapodal plates relatively large, more or less boat-shaped. Peritreme long reaching to beyond the anterior border of Coxa I, stigma distant from the lateral border of the body. Dorsal plate divided, as is characteristic of the genus, with short setae; tubercles on the posterior border very much reduced but their setae long. Legs armed with weak setae.

*Type material*.—Female *holotype* from *Rattus norvegicus* collected at San Juan (San Juan proper), Puerto Rico, May 16, 1947.

*Remarks*.—This new species is distinguished from the other members of the genus by the extreme reduction in size of the tubercles on the posterior border of the notogaster.

## Family Liroaspidae

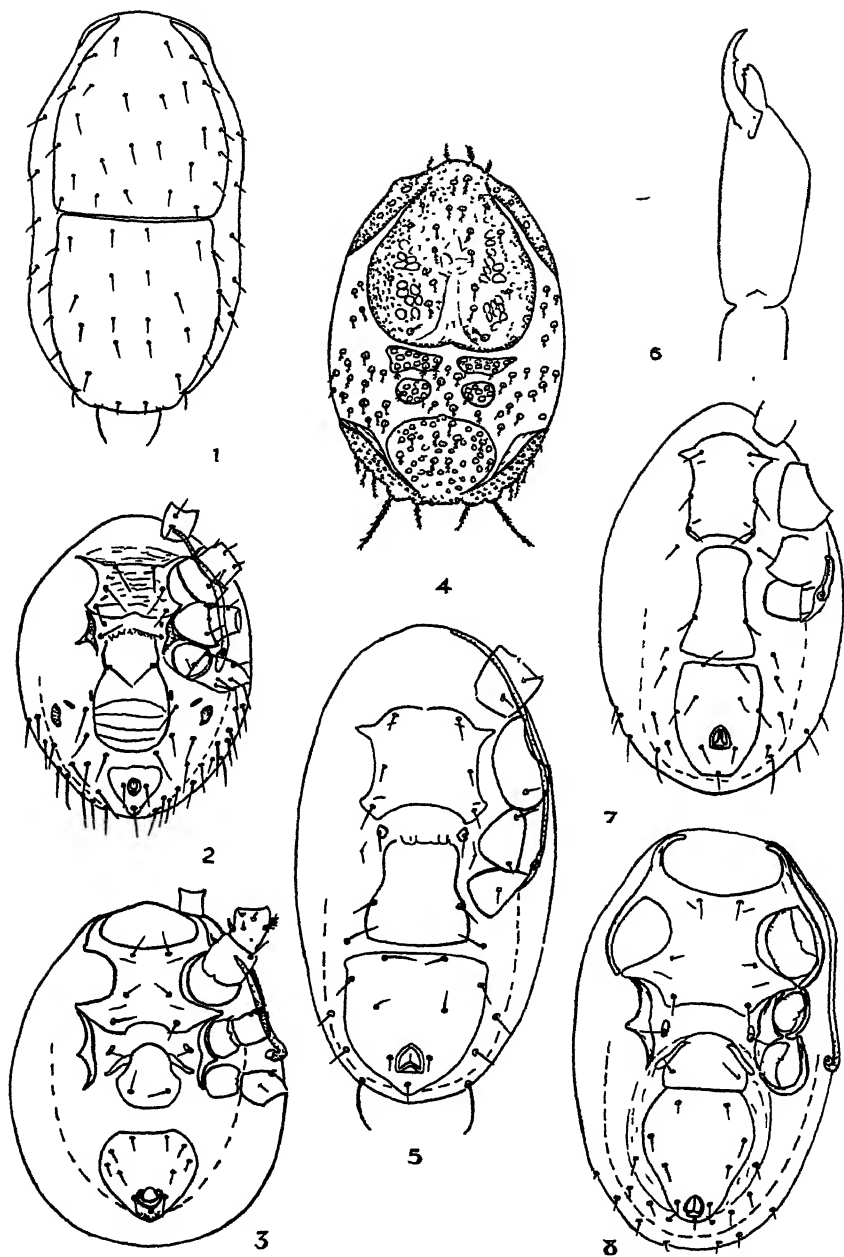
*Liroaspis armatus* n. sp.

## Figure 4

*Female*.—Body abundantly provided with short plumose setae located on small circular plates, about .53 mm. long (exclusive of capitulum) and .37 mm. wide. Chelicerae large, the fixed arm with a large tooth, the movable arm serrate. Sternal area characteristic of the genus with two pairs of setae located on very faint more or less oval sternal plates I and II and a row of four setae on a crescent-shaped plate (sternal plates III and IV) in front of the genital fissure. Genito-ventral plate large reaching to the posterior borders of Coxae IV, armed with three pairs of setae, the fourth pair, usually present, is not discernible. Between the genitoventral and the anal plate are a number of short setae located on conspicuous circular plates. Anal plate more or less circular oddly sculptured with seven pairs of setae in addition to

## EXPLANATION OF PLATE I

1. *Asca muricata* n. sp., female, dorsum.
2. *Atricholaelaps strandmanni* n. sp., female, ventral plates.
3. *Macrocheles cardatus* n. sp., female, ventral plates.
4. *Liroaspis armatus* n. sp., female, dorsum.
5. *Borinquolaelaps setulus* n. sp., female, ventral plates.
6. *Blattiosocius keegani* n. sp., female, chelicera.
7. *Blattiosocius keegani* n. sp., female, ventral plates.
8. *Macrocheles lyratus* n. sp., female, ventral plates.



the anal ones. Paired anal setae located below the middle of the pore, plumose as is the unpaired seta. Posterior border of the body with a large sculptured plate which on the ventral surface bears a pair of plumose setae; dorsally the plate bears two tubercles on a side, not so large as in other species, each of which bears a long plumose seta. Dorsum as shown in fig. 4, the plates oddly sculptured. Peritremes wide, reaching to the middle of Coxa I, the stigma distant from the lateral border of the body. Legs armed with many plumose setae.

*Type material*.—Female *holotype* from *Rattus rattus (alexandrinus?)* collected at San Juan (Santurce), Puerto Rico, June 11, 1947; female *paratype* from *Rattus norvegicus* collected at San Juan (Puerta de Tierra), Puerto Rico, April 9, 1947.

*Remarks*.—This new species is similar to *L. togatus* (Koch), but differs in the structure of the tuberculated plate which terminates the abdomen.

### Family Macrochelidae

#### *Macrocheles cardiatus* n. sp.

##### Figure 3

*Female*.—Body sparsely provided with setae, about .81 mm. long (exclusive of capitulum) and about .62 mm. wide. Chelicerae large and toothed. Sternal plate anteriorly with large lateral expansions, setae and pores placed as usual. Metasternal plates small. Endopodal plates large. Genital plate small, posteriorly truncate anteriorly with wing-like expansions, the genital setae about as large as the sternal ones. Metapodal plates not discernible. Ventro-anal plate more or less heart-shaped, well separated from the genital plate, provided with four pairs of short setae in addition to the anal ones. Anal pore posteriorly removed by a sclerotized area which does not reach to its anterior border. Basal portion of the peritreme forming a hook and extending beyond the lateral border of the body, anteriorly reaching to the middle of Coxa II. Dorsal plate not covering the entire dorsum, allowing large margins laterally and posteriorly. Legs provided with large setae, some of which are plumose.

*Type material*.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, January 3, 1947.

*Remarks*.—This new species is similar to *M. fonsecai* Fox from which it may be distinguished by the differently shaped ventro-anal plate which is distant from the genital one.

#### *Macrocheles lyratus* n. sp.

##### Figure 8

*Female*.—Body provided with short setae, about .68 mm. long (exclusive of chelicerae) and .43 mm. wide. Chelicerae large, toothed. Sternal plate large with broad lateral expansions anteriorly from which arise the large curved endopodal plates II which encircle Coxae II; sternal setae short placed as usual. Endopodal plates III and IV strongly sclerotized encircling Coxae III and IV. Metasternal plates well sclerotized their setae located at the posterior ends. Genital

plate truncate posteriorly its setae short. Ventro-anal plate inverted lyre-shaped, contiguous to the genital plate, provided with three pairs of setae in addition to the anal ones. Paired anal setae located slightly above the middle of the pore and somewhat distant from the latter. Flanking the posterior portion of the ventroanal plate are four setae on each side. Metapodal plates not discernible. Peritreme basally extending beyond the lateral border of the body, anteriorly reaching to beyond Coxa I. Dorsal plate not covering the whole dorsal surface, provided with short broad setae.

*Type material*.—Female *holotype* from *Rattus norvegicus* collected at San Juan (Santurce), Puerto Rico, May 2, 1947.

*Remarks*.—This new species is similar to *M. alatus* Fox from which it differs in being much larger in size and in having the ventro-anal plate contiguous to the genital one.

#### ACKNOWLEDGMENTS

Thanks are due to Dr. Ivar Trägårdh, R. Swedish Institute of Experimental Forestry, Experimentalfältet, Sweden for helpful advice; and to Dr. R. W. Strandtmann, University of Texas, Capt. Roy F. Fritz, U. S. Public Health Service, and Gordon B. Thompson, Science Museum, Institute of Jamaica, for generous gifts or loans of specimens.

NATURE AND PREVENTION OF PLANT DISEASES, by K. STARR CHESTER. Second Edition, xi+525 pages, 224 figures, 1947. The Blakiston Company, Philadelphia and Toronto. Price \$5.00.

The purpose of this book, according to the preface, is to meet the needs of students whose training in plant pathology is to be limited to a semester or to a year. For them the author offers a survey of "the leading diseases of the major crops grown extensively in the United States, . . . the recognition of these diseases, . . . and the latest generally approved methods of their control." He also includes a survey of the underlying principles of plant pathology.

In the first nine chapters fungous diseases are treated. Separate chapters cover rusts, smuts, fleshy fungi and mycorrhizae, ascomycetes, imperfect fungi, physomycetes and related fungi, and damping off and related troubles. Chapter 10 covers bacterial diseases, chapter 11 viruses, and chapter 12 diseases caused by parasitic seed plants and algae. Diseases caused by nematodes are considered in chapter 13 and physiogenic diseases in chapter 14. The remainder of the book is devoted to principles and methods of control. Chapter 15 includes methods of study, chapter 16 the relations of environment to parasitic diseases and chapter 17 the etiology and epiphytology of disease. Chapter 18 considers the control of diseases by regulation, such as quarantine, chapter 19 control by inducing resistance, and chapter 20 control by cultural methods. Each chapter is concluded with a bibliography and the book ends with a glossary and an index.

The role of insects as vectors of plant diseases is considered and the methods of control necessarily overlap those which are familiar to entomologists, although the writer adheres closely to the major purpose of his book. Because of the close relationship of the two fields, economic entomologists should find the book a valuable source of information. The numerous half-tone illustrations are not of high quality, but the reviewer has noted none which fail to serve their purpose well. In general the book is well organized, well written and altogether excellent treatment of the subject.—A. W. L.



## THE SPECIES OF LAC INSECT STUDIED BY COMSTOCK

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With regard to the origin of the material which Comstock (1) studied in 1880 he says, "From a quantity of commercial stick lac purchased in New York I obtained specimens of an insect which I have no doubt is the *Coccus lacca* of authors." Since the lac insects are cultivated like the silk worm in China or in Italy more information is necessary than the mere record of the locality and of the host plant. For example on *Shorea talura* in the Mysore State the insect, *Lakshadia mysorensis*, is cultivated while a few years ago the same tree bore an encrustation of *Lakshadia communis* which differs from the other in several respects. To those who still believe that there is only one species of lac the question does not arise as to the source of the material Comstock studied. However, it will be shown that a few authors confirm Comstock's findings because they also studied the same species while others do not as they were dealing with an entirely different insect.

The lac insect has been valued for two of its products, in recent times for its resin, better known as shellac, and formerly on account of its red dye for silk and wool. Exactly a hundred years previous to Comstock, in 1780, Swagerman (2) came to the conclusion that there are at least "three sorts of lac and of them all that coming from Siam was the best." That was the age when the dye alone was of value and naturally Swagerman could have only meant that weight to weight stick lac from Siam gave the best yield of lac dye. This is true of *Lakshadia chinensis* material which is cultivated from Assam to Tonkin, including Burma and Siam. Even up to 1880 lac dye was greatly in demand and stick lac was exported for dyeing which makes it probable that Comstock bought specimens belonging to *L. chinensis*. In several Museums of Natural History, on the Continent, the only specimens of lac deposited by the contemporaries of Comstock belong to the same insect. I have had the occasion to examine the specimen of stick lac kept in a show case in the Museum at Prague which belonged to *L. chinensis*, as also did Museum specimens at Vienna, Berlin and Copenhagen.

As late as 1901 Newstead (3) illustrated stick lac belonging to the same species. On Plate I, fig. 1, he has several photographs of stick lac, the largest specimen being placed topmost and free from any twig. Now it is mostly, if not invariably, encrustations of *L. chinensis* that can be easily detached from their twigs. But for this property Newstead's photograph is not typical of this material, which I was, however, able to verify as belonging to *L. chinensis* from some type material kindly sent to me by Prof. Newstead. The lac industry in Indochina depends entirely on *L. chinensis* and Hautefeuille (4) (1924) says with regard to stick lac there, "In Tonkin the product as a whole is larger, more voluminous, thicker and more easily detached from the twig to which it is attached (p. 19)." These properties can be illustrated by a photograph, as fig. 1

here is expected to do. Moreover, as early as 1760, Ledermuller (5) had already discovered the property of stick lac being detached from its associated stick which he tried to illustrate. His figure is reproduced as fig. 2 here. It has been turned upside down for the basal portion of an encrustation is more uniform in outline and the encrustation is thinner than on the upper portion. I further imagine the encrustation was larger and has been broken so that only a portion of it is represented.

Most lac insects feed on twigs .3-.8 cm. in diameter but *L. chinensis* can attack thick stems, 2-4 cm. in diameter. Ledermuller's specimen,

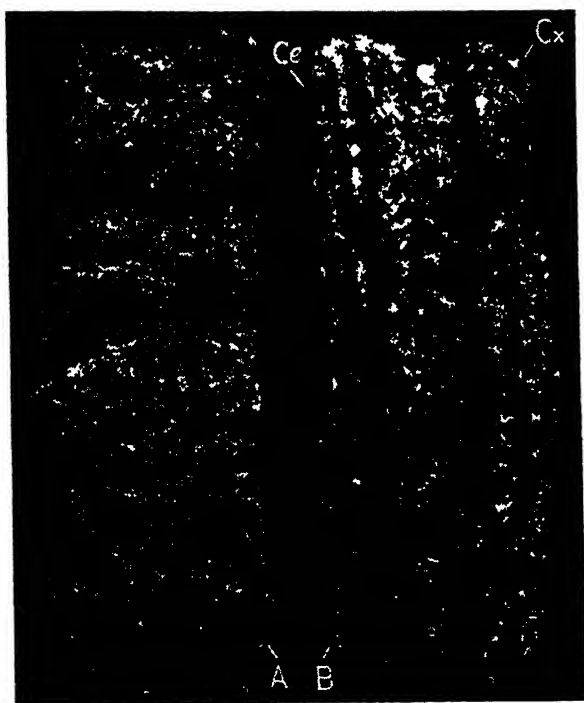


FIG. 1. *Lakshadia chinensis*, encrustations on *Cajanus indicus*, Assam, monsoon season. Twig was easily removed. "B" shows a thicker edge on the more convex, Cx, than on its concave, Ce, side. The hollow central channel shows the thickness of the twig. "A" shows the other surface of the same encrustation. Magnification, 11 : 10.

fig. 2, would bear testimony to this fact. In fig. 1 the central hollow grove is also thick for the other species of lac insects. Its width indicates the diameter of the twig that bore the encrustation.

On a horizontal twig the insects settle only on the lower surface, facing the earth and along the sides of the stem. In fig. 1 the raised portions of encrustations show the two rows of insects that had settled on either side of the horizontal twig. When the horizontal twig is



FIG. 2.

FIG. 2. Encrustation of *Lakshadia chinensis*, detached from a thick stem; the raised edge to the left shows a gradual decline in thickness and indicates its position as it grew in nature. It is Ledermuller's picture, turned upside down. Natural size.

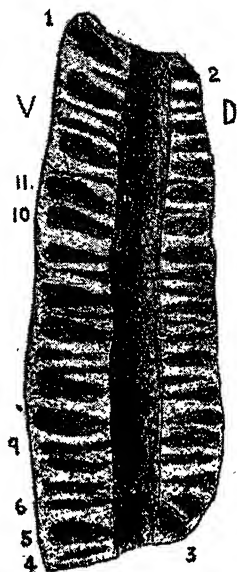


FIG. 3.

FIG. 3. Longitudinal section, natural size, of an encrustation of *Lakshadia chinensis* that had enveloped a twig. It was nearly but not exactly vertical, the side inclined towards the earth is ventral, V, where the row of cells are larger, than cells on the opposite or dorsal side, D. From Comstock.



FIG. 4. *Lakshadia chinensis*, an elongated insect, columnar in shape with a finger-like thin anal tubercle; compare cell No. 1, Fig. 5. From v. Gernet.

curved the convex side shows a better growth of insects forming a marginal encrustation as along the edge Cx, in fig. 1B and a relatively poorer edge along the concave side, Ce, fig. 1B. Fig. 1B shows the encrustation facing the earth and seen from above a horizontal twig; fig. 1A is the same object as in fig. 1B seen reversed and at its best.

On a vertical twig the insects settle all around it and the encrustation is a cylindrical tube enveloping the twig. Comstock gives a longitudinal section of such an encrustation, showing its natural size in his fig. 2, Plate XIX. It is offered here as fig. 3. As far as I know it is the very

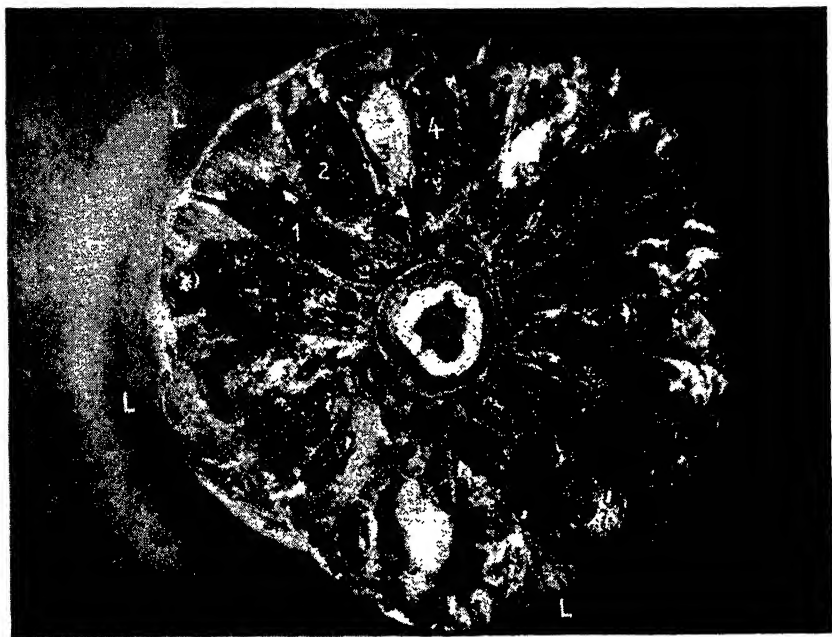


FIG. 5. Cross-section of fresh stick lac of *Lakshadia chinensis*, Nowgong, Assam, with cells of indistinct shape. Cells Nos. 2-4 are almost rectangular in shape with broad upper surface indicated with arrows in Cells 3 and 4. In portions lac secretion is rich, L. Magnification 37 : 10.

first section of lac seen longitudinally. It reveals a honey-comb like structure with cells which were occupied by living insects. But no vertical twig is ideal, the side more inclined towards the earth is to be understood as its ventral side and the opposite as its dorsal side. Fig. 3 shows the encrustation having a better row of cells on the Ventral, V, side than on the Dorsal, D, side. In fig. 3 cell No. 1 for example is top-most on the ventral side and is far bigger than the corresponding cell No. 2 on the dorsal side of the encrustation. The same applies to the row of cells Nos. 4, 10 and 11, which are bigger than the long row of cells on the dorsal side from No. 2 to No. 3.

In all encrustations basal cells are larger than those on the top, e. g., No. 3 in fig. 3 is larger than No. 2. This point is also evident on a careful examination of the picture Ledermuller offers where the raised edge of the encrustation is not uniform throughout its length. It has to be turned upside down and to be shown as it is reproduced here as fig. 2 as already mentioned. In fig. 2 the thick ridge to the left gradually thins towards the top.

Comstock shows fig. 3 free from the twig while later on Green (6) (1922) has a similar picture from material belonging to *L. nagoliensis* but with



FIG. 6. *Lakshadra chinensis* after treatment with cold caustic solution. Insects Nos. 1, 2 and 8 with pads of hard wax on their ventral surface. Insects Nos. 1, 2, 3 and 4, where these figures stand, show sharp corners of the body which has a broad dorsal surface. Insect No. 8 does not show this feature and may be contrasted.

the stick still present. Any one who handles encrustations from these two sources will at once notice how easy it is to remove the stick from *L. chinensis* and how difficult from *L. nagoliensis* lac.

It had been pointed out that cells on the ventral surface, V, fig. 3, are larger. Cell No. 4 and cells Nos. 6-9 are almost linear in their representation. V. Gernet (7) has previously illustrated such a columnar body of a lac insect as thick at the base as it is at the top and his picture is reproduced as fig. 4. Besides its anal tubercle is thin, finger-like and could not be more conspicuous; in no other insect such is the

case with the anal tubercle. Fig. 5 is a cross section of fresh stick lac and there insect No. 1 is likewise as thick at the base as at the top and has a thin, long anal tubercle.

Elongated cells as seen in fig. 4 were examined carefully. Eggs were found fully formed. From some larvae had also swarmed so that they represent individuals that had become mothers and are thus fully developed. In fig. 3 Comstock shows cells Nos. 10 and 11 rectangular in shape. These are not idealized representations. Fig. 5 shows insect No. 2 almost rectangular and cells Nos. 3 and 4 are approaching it. The white arrows indicate in cells Nos. 3 and 4 the broad and straight shoulders, as it were, of these insects. In fig. 3 Comstock further indicates cells Nos. 10 and 11 and others a little to the interior of the marginal line. In fig. 5 portions where lac secretion is thick are marked, L, and this feature shows the insects well covered with a thick secretion of lac; insects Nos. 1 to 4 are all beneath the outline of the circumference.

Fig. 5 shows the shape of the cells as very irregular. This is a photograph and hence represents typical features of the encrustation belonging to *L. chinensis*. Fig. 6 shows the individual lac insects of this species. Insects Nos. 1, 2 and 8 have thick pads of ventral hard wax which has been previously illustrated (8). In this species the glutinous portion of ventral wax is very large and such pad like appearance is peculiar to *L. chinensis*. Insects Nos. 1, 2, 3 and 4 where these figures stand show a broad and flat surface of the body with the anal tubercle. In no other lac insect is this the case; this confirms the shape of cells 10 and 11 in fig. 3 from Comstock. Fig. 5, cell No. 5, shows one side as a straight line and the other as a semicircle. In fig. 6 insect No. 7 has the identical shape and so is almost insect No. 4. In fig. 6, the anal tubercles of insects Nos. 5 and 6 are not so thin as in insect No. 1 of fig. 5 but the former compare well with the previous illustration given by Tozzetti who also represents the same species in his fig. 12 as reproduced by Gascard (9).

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## NOTES ON THE PHLEBOTOMUS OF PANAMA (Diptera, Psychodidae)<sup>1</sup>

### I. THE SUBGENUS BRUMPTOMYIA FRANCA AND PARROT 1921

G. B. FAIRCHILD<sup>2</sup> AND MARSHALL HERTIG<sup>3</sup>

In 1943 one of us (Fairchild 1943) listed the *Phlebotomus* species then known from Panama, four described species and two other undetermined species which appeared to be new. In the subsequent four years we have made a special effort to collect these insects, using more effective techniques, and have amassed an estimated 10,000 specimens representing about 30 species. We hope to report on this material in a series of papers, of which this is the first.

The terminology of the structures useful in the taxonomy of *Phlebotomus* has evolved more or less independently, and the homologies with structures in other Diptera and other orders of insects remain incompletely worked out. We have chosen to use, with slight modification, the terminology of Christophers and Barraud (1926) and Tonnoir (1935), because we feel it to be the simplest, and because there seems to be no general agreement as to terminology among students of Diptera. We give below the terms to be used in this and subsequent papers, with some of their equivalents.

The *ascoids* or geniculate spines are apparently hollow spine-like structures of presumed sensory function found in pairs on all but the last few flagellar segments of the antennae; their shape and size are often of considerable taxonomic importance. The *cibarium*, buccal cavity, buccopharynx or anterior pharynx lies within the clypeus. It is a flat rectangular box-like structure usually bearing vertical and horizontal teeth on the proximal margin of its ventral side. These teeth are generally absent in the male, but their number and arrangement offer good characters in the female. There is also an arched ridge-like thickening of the ventral surface, the *chitinous arch* which seems to be the attachment of the salivary muscle. The chitinous arch is sometimes not visible centrally, and its degree of development and position offer good taxonomic characters. This structure has been neglected as a character of taxonomic importance, Hertig (1938) having first called attention to its utility. The *pigmented area* often seen just distal to the cibarial teeth, is on the dorsal surface of the cibarium and is the place of attachment for the posterior clypeal muscles according to Theodor (1932). The term "cibarium" was suggested to us by Dr. C. D. Michener as being more exact and concise than its more generally found equivalents. The *pharynx* or posterior pharynx lies within the head capsule. It appears to be longitudinally folded in somewhat the manner of a

<sup>1</sup>This work was initiated under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and development and the Gorgas Memorial Laboratory.

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child's paper dart, and is triangular or three-winged in cross-section. It bears spines, teeth or ridges on its posterior end which are often of considerable taxonomic value.

The male *genitalia*, terminalia or hypopygia, are of paramount importance in the classification of the group. As is now well known, the genitalia are rotated through 180° soon after eclosion, so that the morphologically ventral parts become dorsal and vice versa. To avoid confusion, we will describe the parts as they appear on the insect. The most dorsal structures are a pair of two-segmented appendages, called the upper claspers or superior gonapophyses. The basal segment is the *coxite*, basal segment of upper gonapophyses, basistyle, side piece or gonostipes. It is simple or bears spines, modified setae or tufts of various sorts. The *style* is the terminal segment, dististyle or clasper, and bears from one to five or more strong spines. The *parameres*, intermediate appendages, median gonapophyses or median claspers, are situated below and at the base of the coxites. They may be simple, forked or branched and with or without spines, tufts of hairs or modified setae in various situations upon them. Between the parameres lies the *aedeagus*, intromittent organ, penis sheath, phallosome, mesosome or gubernaculum. It is a heavily sclerotized, more or less triangular structure, seemingly formed of two partially fused tubes through which pass the *genital filaments*, penis filaments or spicules, which are themselves tubular. Both structures show modifications of taxonomic value. The filaments pass into the abdomen and join in a heavily sclerotized structure known as the *genital pump*, or pompetta, which is believed to act as a pump to force the sperm through the genital filaments. Attached close to the base of the genitalia ventrally are two unsegmented appendages, the *lateral lobes*, lower claspers or inferior gonapophyses. They are usually at least half the length of the coxites, and may be much longer, slender or inflated, and occasionally with spines or modified setae at their tips. Below and between the lateral lobes lie the *cerci*, anal lobes, proctigers, submedian lamellae or membranous processes. They seem homologous with the female cerci, and indeed in some species where those of the female are of unusual shape, those of the male also have the same shape. They are generally rather uniform throughout the group, and are often omitted from figures and descriptions, though in some cases they are useful in associating the sexes.

Students of *Phlebotomus* have used for many years Greek letters to indicate certain parts of veins whose relative lengths are of taxonomic importance. Tonnoir (1935) established the homologies of these veins, but realized the convenience of the use of Greek letters and continued to employ them. Alexander (1944) condemned their use under the impression that they constituted new names for the veins. In reality the Greek letters stand only for certain definite segments of veins whose measurements projected onto a line tangent to the costa are used in calculating certain proportions believed to be of taxonomic value. Since their use is a great convenience and does not conflict with the established nomenclature of the veins, we shall continue to use them. *Alpha* corresponds to vein  $R_2$  from its junction with  $R_3$  to the costa. *Beta* corresponds to the segment of  $R$  from the junction of  $R_2$  and  $R_3$



to its junction with  $R_4$ . *Gamma* corresponds to the section of  $R$  from the forking of  $R_4$  to the junction of  $R_5$ . *Delta* is the section of  $R_1$  which overlaps the junction of  $R_2$  and  $R_3$ .  $R_1$  occasionally fails to reach or just reaches the junction of  $R_2$  and  $R_3$ , in which cases *Delta* is negative or zero. In our experience, the venational characters so extensively used by some previous workers have proven of rather limited value. With certain exceptions, notably the length of *Delta* relative to *Alpha*, they are of little help in separating closely allied species or in associating the sexes of the same species, and are not to be relied upon in the absence of other supporting characters.

The detailed measurements so often included in descriptions we find unnecessary. If the species shows good structural characters the measurements are largely superfluous; if it does not, the measurements are hardly to be relied upon to characterize it. We have therefore confined ourselves to the following measurements: total wing length, alpha, beta, gamma, delta, third antennal segment, palpal segments, head length, clypeal length, proboscis and vertical eye length. In some cases other measurements have been included where the structure concerned is particularly striking.

In measuring the palpi, we have combined the first and second segments, as the suture between them is oblique, often not distinct, and the first segment varies little in length. The so-called palpal formula, in which the segments are listed in order of increasing length, we have abandoned as useless. In many species two or more segments may be subequal, but varying sufficiently individually to yield different palpal formulas for different individuals of the same species. Conversely, quite distinct species with palpi of markedly different lengths may have the same palpal formula. Palpal measurements are useful in associating sexes, but tend to be a group character, several closely related species sharing the same measurements.

#### Subgenus *Brumptomyia* Franca and Parrot

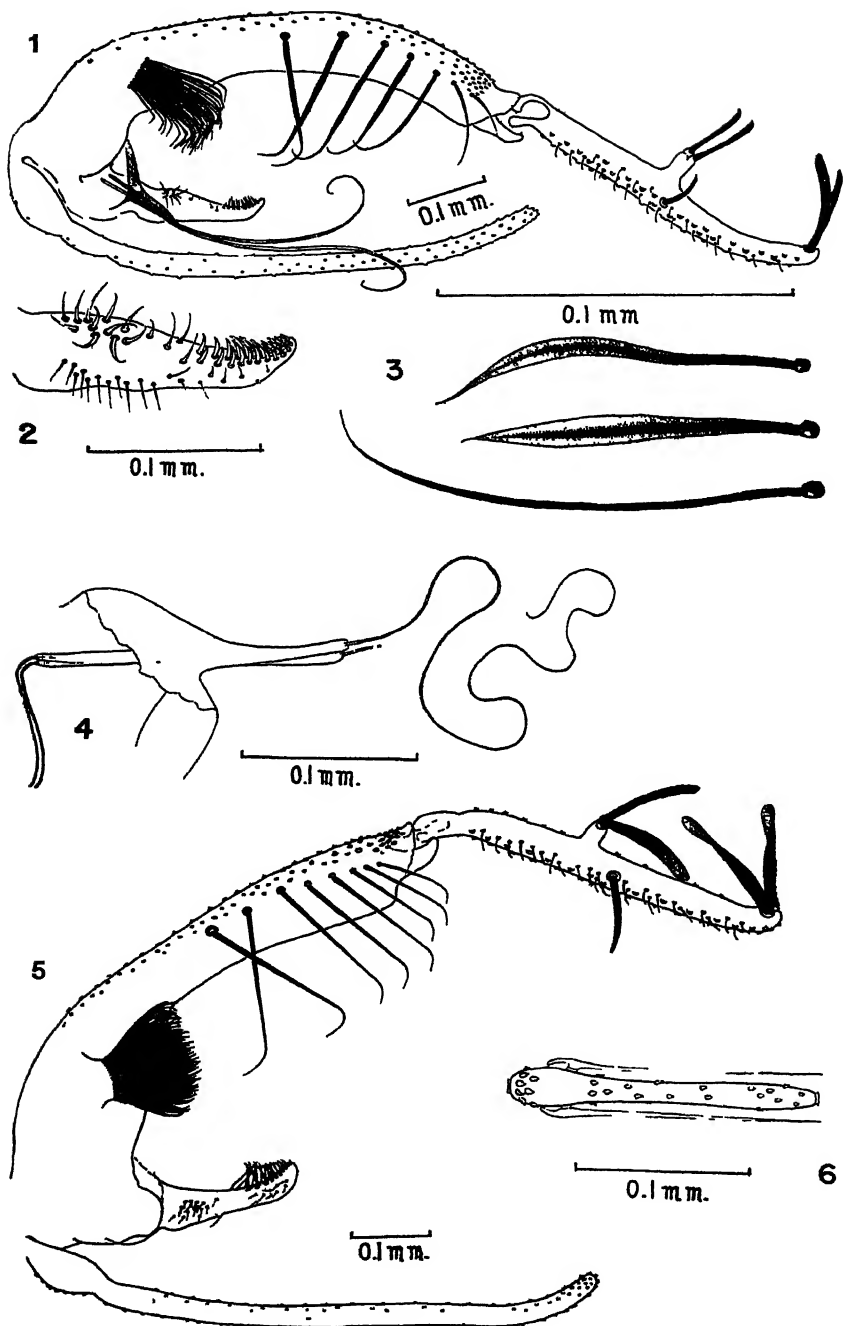
1921, Arch. Inst. Pasteur de l'Afrique du Nord, 1, (3), pp. 280, 281, 283, fig. 4 (with *Ph. brumpti* Larr. and *Ph. vexator* Coq.). Dyar, 1929, Am. J. Hygiene, 10, (1), p. 112. (Subgenotype *P. brumpti* Larrousse.) Mangabeira, 1942, Mem. Inst. Oswaldo Cruz, 37, (2), pp. 208-210. Mangabeira and Galindo, 1944, Am. J. Hygiene, 40, pp. 189-190.

Mangabeira and Galindo (l. c.) have redefined the group and include ten neotropical species. Three species, *travassosi*, *avellari* and *guimaraesi* have been reared, and the morphology of the early stages and females described (Coutinho and Barreto 1941; Mangabeira 1942). *P. spinosipes* Floch and Abonnenc 1943, described from the female, has all the characters of the subgenus and could be placed here without hesitation were it not for the peculiar peg-like spines on the hind femora. These are reminiscent of the spines found on the hind femora of *P.*

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#### EXPLANATION OF PLATE I

FIG. 1, *Phlebotomus hamatus*, internal aspect of genitalia, side view. FIG. 2, internal aspect of paramere of *P. hamatus*. FIG. 3, *P. galindoi*, spines of basal tuft. FIG. 4, aedeagus and genital filaments of *P. galindoi*. FIG. 5, *P. galindoi*, genitalia. FIG. 6, eighth flagellar segment of antenna of *P. galindoi*, showing ascoids.



*fischeri* and related species, on the basis of which Costa Lima erected the subgenus *Pintomyia*. However, the spines on *spinosipes* are peg-like, not sharply pointed as in *fischeri* and allied forms. In both cases they seem but modifications of the long setae usually found in the same situation.

The three species occurring in Panama are apparently quite rare, and we have taken no females referable to *Brumptomyia*. We have added a key to the males of the known species of the subgenus. The females are so similar that in most cases they are practically impossible to identify with certainty.

***Phlebotomus (Brumptomyia) hamatus* sp. nov.**

Figs. 1 and 2

This species is separated from *P. travassosi* Mang. 1942, its nearest relative in the subgenus *Brumptomyia*, by the differently shaped parameres, the greater number and development of the distal spines on the inner aspect of the coxite, the less dense basal tuft borne on a raspberry-like tubercle, and the shorter and less attenuated genital filaments. The ascoids appear to reach almost to the distal ends of their respective segments, and to have a short proximal prolongation, as figured for *travassosi* by Floch and Abonnenc (1942). The name is from Latin *hamatus*—bearing hooks.

The measurements of two of the three specimens at hand are given below in micra. The third specimen is much shrunk and accurate measurement is impossible.

Slide 112. Holotype. Third antennal segment, 384. Palpal segments: 1+2, 132; 3, 128; 4, 92; 5, 220. Wing: total length 2160; *Alpha*, 630; *Beta*, 234; *Gamma*, 342; *Delta*, 90. Head measurements: vertex to fronto-clypeal suture, 300; clypeus, 100; proboscis, 204; vertical eye length, 268.

Slide 222. Paratype. Third antennal segment, 340. Palpal segments: 1+2, 120; 3, 128; 4, 88; 5, 256. Wing not measurable. Head measurements: vertex to fronto-clypeal suture, 244; clypeus, 100; proboscis, 204; vertical eye length, 268.

*Holotype* male, Chilibrillo bat caves near Chilibre, Panama. Dec. 4, 1943. Taken from a crevice in limestone rock near the entrance to the caves. *Paratype* male, Cruces Trail, Madden Dam highway, Canal Zone, May 14, 1944. From between buttressed roots of a large hollow tree containing bats about 200 yards from highway along old Cruces Trail. *Paratype* male, Chorrera, Panama, 9 July 1944. Taken in an animal burrow. Types to be deposited in the Museum of Comparative Zoology, Cambridge, Mass.

***Phlebotomus (Brumptomyia) travassosi* Mangabeira**

1942. Mem. Inst. Oswaldo Cruz, 37, (2), pp. 201-205, figs. 137-142. (♂; Belem, Para, Brasil. In Armadillo burrows.) Op. cit., (3), pp. 375-382, figs. 1-14 (♀, larva, pupa). Floch and Abonnenc, 1945. Inst. Pasteur de la Guyane, Pub. No. 100, pp. 1, 7; Pl. 3 (♀).

*Phlebotomus brumptii* Floch and Abonnenc, 1942, Inst. Pasteur de la Guyane, Pub. No. 38, pp. 10-14, figs. 5-6. (♂, ♀; ? French Guiana); 1943, Op. cit., Pub. No. 62, p. 8 (♂; in key only).

A single male, La Victoria, Cerro Jefe, 2400 ft. elev. Oct. 4, 1946, Pedro Galindo coll. This specimen was secured from an armadillo burrow. Subsequent trips to the same locality have failed to yield additional material. This species differs from *hamatus* in the much denser basal tuft of the coxite, the more slender and more sparsely haired parameres, the lighter and fewer apical spines on the coxite and in the much longer and finer genital filaments. Measurements of our single specimen show no differences in wing and palpal proportions from *hamatus*.

***Phlebotomus* (*Brumptomyia*) *galindoi* sp. nov.**

Figs. 3-6

This species is somewhat larger than the two preceding in nearly all measurements and differs from both in various details of the genitalia, among which may be mentioned the heavy blade-like spines of the basal tuft, the more distal position of the unpaired spine on the style, and the very long genital filaments. Its closest relatives appear to be *P. brumpti* Larr. and *P. avellari* C. L. From the former it differs in the more distal position of the unpaired spine of the style, the more numerous, more flattened spines of the basal tuft, which are borne on a definite tubercle, the more slender parameres, which also lack dense dorsal hairs at their bases, and in the more slender and tubular aedeagus. From *avellari* the present species differs in the more slender parameres, and in the structure of the style and basal tuft.

The measurements of the unique holotype are given below in micra. Third antennal segment, 440; palpal segments: 1+2, 172; 3, 160; 4, 112; 5, 292; wing length, 2, 934; alpha, 828; beta, 342; gamma, 450; delta, 180.

Holotype male, 4 miles north of Boquete, Chiriqui Province, Panama. 4000 ft. elevation, 17 February 1947. Taken sweeping with a net. P. Galindo collector. To be deposited in the M. C. Z.

**KEY TO BRUMPTOMYIA MALES**

1. Coxite with a prominent basal tuft of hairs on the inner aspect. . . . . 2  
Coxite without such a tuft, though with a few small scattered hairs, . . . . . *cardosoi* B. and C.
2. Basal tuft of very numerous fine hairs implanted in several contiguous straight rows. Parameres finger-like, slender. Spines of style in two groups, two apical and three median. . . . . *travassosi* Mang.  
Basal tuft otherwise. . . . . 3
3. Basal tuft implanted on a circular patch or raspberry-shaped tubercle. . . . . 4  
Basal tuft diffuse, the hairs well separated and the area of implantation not differentiated. . . . . 10
4. Basal tuft of long fine hairs. . . . . 5  
Basal tuft of short stout spine-like hairs. . . . . 8
5. Spines of style in three distinct groups. . . . . 6  
Spines of style in but two distinct groups. . . . . 7
6. Spines on distal half of coxite, 6, with an additional single spine well separated from the others and near the middle of the segment. Parameres rather short and stout. . . . . *guimaraesi* B. and C.  
Spines on distal half of coxite, 4, no additional spine. Parameres slender and finger-like. . . . . *cunhai* Mang.

7. Spines on distal half of coxite 4, rather small and slender. Parameres very slender, clubbed. Genital filaments exceedingly long and thread-like, *mangabeirai* B. and C.  
Spines on distal half of coxite, 7, the basal 5 straight, heavy and long. Parameres slipper-shaped. Genital filaments thread-like at their apices, not unusually long..... *hamatus* sp. nov.
8. Spines of style in two groups, 2 apical and 3 median.....9  
Spines of style in three groups, 2 apical, 2 median and 1 slightly distal of the median group. Parameres with dense hairs only apically. Hairs of basal tuft flattened and blade-like, borne on a distinct tubercle. *galindoi* sp. nov.
9. Parameres short and broad, not twice as long as wide. Tuft on base of coxite of short heavy spines..... *avellari* C. L.  
Parameres more slender, finger-shaped, with rather dense hairs dorsally on the basal part. Tuft on base of coxite of more numerous and more slender spine-like hairs..... *brumpti* Larr.
10. Spines of style consisting of 1 apical, 1 subapical, 1 median and 2 basal, the last paired on a tubercle. Parameres slender and finger-like with numerous heavy bristles on the dorsal surface..... *pintoi* C. L.  
Style always with an apical pair of spines.....11
11. Parameres stouter, finger-like. Median spine of style well separated from basal pair..... *nitzulescui* C. L.  
Parameres thickened and spinose basally and with slender apical dorsally directed, finger-like process. Median spine of style at same level as basal pair..... *trogodytes* Lutz

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## NOTES ON THE PHLEBOTOMUS OF PANAMA (Diptera, Psychodidae)

### II. DESCRIPTIONS OF THREE NEW SPECIES<sup>1</sup>

G. B. FAIRCHILD<sup>2</sup> AND MARSHALL HERTIG<sup>3</sup>

The three species here considered form an apparently closely related group which is set off from the large group of Neotropical species bearing a basal tuft on the coxite by their inflated lateral lobes and the extreme proximal position of the basal spine of the style. Within the group, *vesiciferus* and *vespertilionis* are most similar in respect to the structure of the male genitalia, both having but three spines on the style, while *deleoni* has four. *Vesiciferus* and *deleoni* have identically formed genital filaments, while those of *vespertilionis* are of a different type. In the females which we have associated with these males, the cibaria are of similar type in all, bearing four strong horizontal teeth and what appear to be two strong vertical teeth as well as a variable number of smaller teeth. The pharynges of all are relatively unarmed, having weak finger-like ridges at their proximal ends only. These ridges bear minute spines, visible only at high magnification. The spermathecae of *deleoni* and *vesiciferus* are of a distinct and unusual type, being apparently somewhat like those figured by Addis (1945, J. Parasit., 31, 2, 119-127) for *P. anthophorus*. The spermathecae of *vespertilionis* are less unusual in structure. Addis erected a new subgenus for his *P. anthophorus*, and indeed the peculiar genitalia, spermathecae and cibarium of his species seem to warrant such an action. However, various of the three species here considered share with *anthophorus* the unusual spermathecal structure and the 3-spined style of the genitalia, while the structure of the paramere is paralleled in a number of not apparently otherwise related species.

#### *Phlebotomus vespertilionis* sp. nov.

##### Plate I

*Male*—Genitalia as figured. The genital pump and filaments are short, the whole structure being but slightly longer than the lateral lobe. The filaments are rather heavy, finely annulated, and about twice as long as the pump. The basal tuft on the coxite shows considerable variation in the number of hairs, the specimen figured having about the maximum number, while others may have as few as half this number. The margin of the coxite below the basal tuft is quite heavily sclerotized and thickened in this as well as the other two species of the group, but this is not shown in the figures due to the difficulty of portraying it beneath the basal tuft. The parameres curve inward in

<sup>1</sup>This work was initiated under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Gorgas Memorial Laboratory.

<sup>2</sup>Medical Entomologist, Gorgas Memorial Laboratory, Panama, R. de P.

<sup>3</sup>Major, Sanitary Corps, Army of the United States.

undistorted mounts as shown in the figure. In more flattened mounts the paramere may appear broader and straighter. The measurements of wings, palpi, etc., of the three species here considered will be found consolidated in Table I.

*Female*—Spermathecae, cibarium and pharynx as figured. Cerci rather short and blunt. Ascoids (in both sexes) simple, long, nearly attaining distal ends of segments.

*Holotype* male, Slide 761, Cerro Campana, Panama Province, Panama, 17 Jan., 1947, =2500 ft. elev. in a shallow cave with bats.

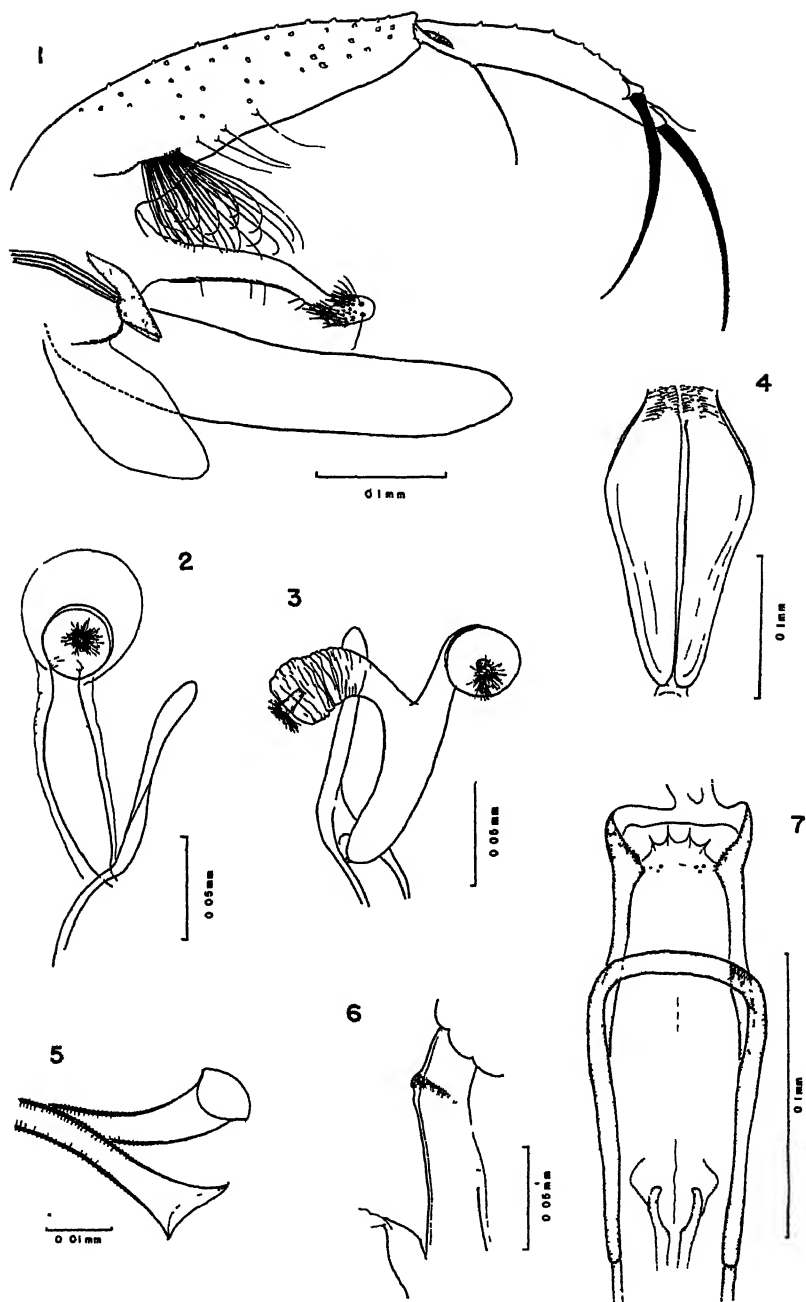
TABLE I  
MEASUREMENTS IN MICRA

	<i>P. vesiciferus</i>						<i>P. vespertilionis</i>						<i>P. deleoni</i>	
	Maximum		Minimum		Mean		Maximum		Minimum		Mean		♂	♀
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀		
Ant. III.....	388	368	328	260	358	313	428	400	304	324	380	352	368	380
Palpi I+II...	140	160	112	120	132	142	148	180	120	148	186	176	160	192
Palpi III.....	140	160	120	112	132	138	152	160	124	140	140	145	160	172
Palpi IV.....	88	100	72	76	80	84	92	100	72	88	80	93	120	128
Palpi V.....	224	224	200	180	206	200	264	272	204	212	228	236	.	332
Head height..	236	252	212	200	225	236	284	304	236	256	256	278	224	224
Clypeus.....	140	152	92	112	110	134	120	160	100	124	113	140	128	160
Proboscis....	192	268	148	200	173	238	216	260	172	220	191	248	180	260
Eye height...	176	192	128	144	153	170	212	236	160	180	182	209	148	180
Wing length...	1740	1940	1450	1640	1570	1780	1960	2160	1580	1850	1780	1960	1530	1800
Alpha . . . .	522	630	396	500	439	550	486	630	396	522	450	552	414	558
Beta... . .	216	252	162	180	192	217	288	306	216	252	252	275	198	252
Gamma. . . .	306	360	216	234	261	293	324	360	252	270	288	302	234	306
Delta . . . .	270	360	182	270	212	315	216	342	144	252	180	280	126	306

*Allotype* female, Slide 742, Chorrera, Panama, 1 Dec., 1946, in forest S. E. of town in hollow tree with bats. *Paratypes*, 33♂, 34♀ mounted on slides and 539♂, 687♀ in alcohol, from the following localities: Canal Zone—Juan Mina Sta., Chagres River region; Rio Pequeni, head of Madden Lake; Gatuncillo, Chagres River region; Chiva Chiva road; Cruces Trail, Canal Zone Forest Reserve. Republic of Panama—Panama Province; Pacora; near Arraijan; Chorrera; Cerro Campana; La Victoria, Cerro Jefe, nr. Tocumen; Chilibrillo bat caves, nr. Chilibre; Bejuco. Veraguas Prov.—Santa Fe. Colon Prov.—Puerto Pilon.

#### EXPLANATION OF PLATE I

*Phlebotomus vespertilionis*. FIG. 1, male genitalia, inner aspect. FIG. 2, spermatheca, drawn from a specimen cleared in phenol without treatment in KOH to show cellular envelope surrounding spermatheca. FIG. 3, spermatheca, drawn in water from a specimen treated with KOH. FIG. 4, female pharynx, balsam mount. FIG. 5, tips of male genital filaments. FIG. 6, female chitinous arch, lateral view, as seen in mount of whole head cleared in phenol. The ventral side is to the left. FIG. 7, female cibarium, stained and mounted specimen, ventral view.





Bocas del Toro Prov.—Changuinola District, United Fruit Company Plantation.

This material was collected on 52 different occasions in every month of the year, from 1944 to 1947. Females were invariably associated with bats, either in hollow trees or in hiding places near the entrances to bat caves. Males were taken fairly frequently between the buttressed roots of large trees in the forest and once beneath boulders in a dry stream bed, as well as in bat roosts. Collecting data seem to show greater abundance from June to December, the rainy season, than from January to June, the dry season, although we have insufficient records to plot the seasonal abundance in detail. Specimens have been taken from sea-level up to about 2500 ft. elevation.

We feel quite confident that this species, if not restricted to bats as its host, at least shows a great preference for these mammals as a source of its blood meal. Only rarely have we failed to find this species present in bat roosts in hollow trees, and the females have never been secured in other situations. Some bat trees have yielded enormous numbers of this species, and this species only, and it is customary to find a high proportion of the females engorged with fresh or partially digested blood.

### *Phlebotomus vesiciferus* sp. nov.

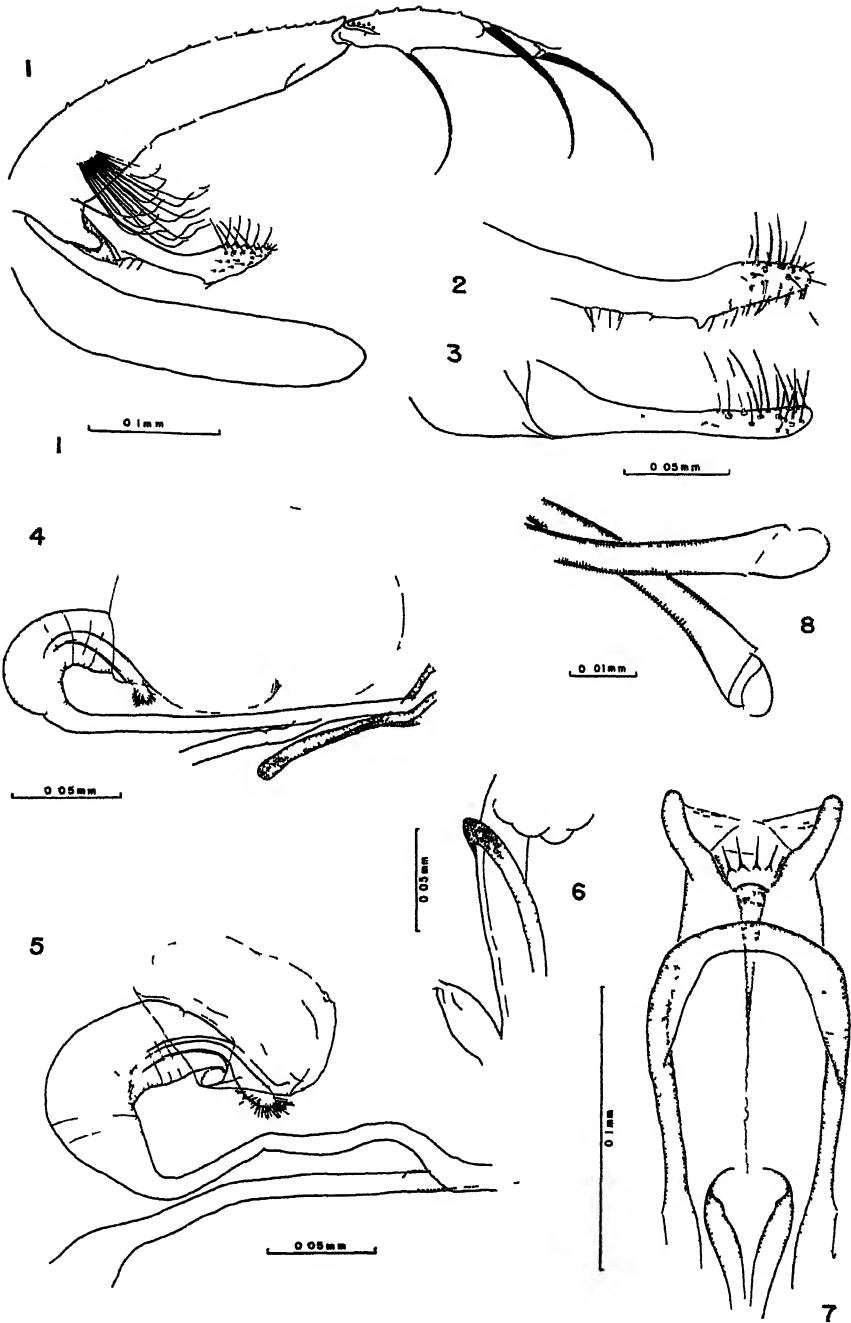
#### Plate II

*Male*—Genitalia as figured. The shorter lateral lobes and heavier basal spine of the style are characteristic. The genital pump and filaments are short, but slightly longer than the lateral lobes, and except for their tips, like those of *vespertilionis*. The basal tuft on the coxite shows variation in the number of hairs, but these are generally fewer than in the preceding species. The cerci are relatively longer and somewhat more acutely pointed than in *vespertilionis*. Ascoids in both sexes simple, nearly reaching ends of their respective segments.

*Female*—Cibarium and spermatheca as figured. Pharynx as in *vespertilionis*. The unusual structure of the spermatheca seems to be due to an enormous asymmetrical inflation of the terminal portion of the body of the spermatheca, which enfolds and overgrows the head, displacing it laterally so that it appears to emerge through an aperture at the side of the body of the spermatheca. From the figures given by Addis (1945) a somewhat similar situation seems to obtain in *P. anthophorus*, though here what we take to be the inflated portion is lobulated, while in our species it is simple and bladder-like. The true appearance is difficult or impossible to discern in permanent mounts, as the exceedingly tenuous walls of the inflated portion invariably

#### EXPLANATION OF PLATE II

*Phlebotomus vesiciferus*. FIG. 1, male genitalia, inner aspect. FIGS. 2 and 3, parameres of another example, showing variation of appearance due to orientation, fig. 3 being a dorsal view. FIG. 4, spermatheca, cleared in phenol. FIG. 5, spermatheca in water after KOH treatment. The specimen is somewhat flattened and the bladder collapsed and shrunken. FIG. 6, chitinous arch of female, side view, for comparison with Plate I, fig. 6. FIG. 7, female cibarium, ventral view. FIG. 8, tips of genital filaments.



collapse during mounting. Our figures were drawn from a specimen cleared in phenol and from one mounted in water after treatment with KOH. The name is from Latin *vesicus* = a bladder.

*Holotype* male, Slide No. 680, Cruces Trail, Canal Zone Forest Reserve, 24 Nov., 1946. Taken in a large hollow tree containing bats.

*Allotype* female—Slide No. 667, Cruces Trail, Canal Zone Forest Reserve, 16 Nov., 1946. Taken in a large hollow tree containing bats.

*Paratypes*—7 ♂, 5 ♀, mounted on slides and 44 ♂, 1 ♀, in alcohol from the following localities: Cruces Trail, C. Z. Forest Reserve, in hollow tree with bats, 24 Nov., 1946 (1 ♀); Bocas del Toro, Panama, 1 Feb., 1947, in bat caves (1 ♂, 1 ♀); La Victoria, Cerro Jefe, near Tocumen, Panama, =2500 ft. elev., 23 Jan., 1947, in animal burrows (44 ♂, 1 ♀) and in rock crevices (1 ♀); Cerro Campana, Panama, =2500 ft., 18 Jan., 1947, in hollow tree with opossum (1 ♀); Changuinola District, United Fruit Co. Plantations, Bocas del Toro Province, Panama, 16 Aug., 1944, in buttresses of large tree (1 ♀); Cerro Tute, Santa Fe, Veraguas Province, Panama, 20 March, 1947, in buttress of tree (1 ♂); Canal Zone Police Substation, Rio Pequeni, Madden Lake, C. Z., 22 June, 1944, in buttresses (1 ♂); Juan Mina, Chagres river region, C. Z., 30 May, 1944, in hollow tree with bats (1 ♂); Puerto Pilon, Colon Province, Panama, 2 Feb., 1947, in buttresses (3 ♂).

We have only once encountered this species in numbers, in an animal burrow, and nearly all were males. It seems to show no special predilection for bats, and we have no clear indication of what its preferred host may be.

### *Phlebotomus deleoni* sp. nov.

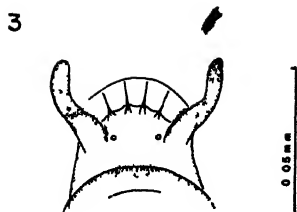
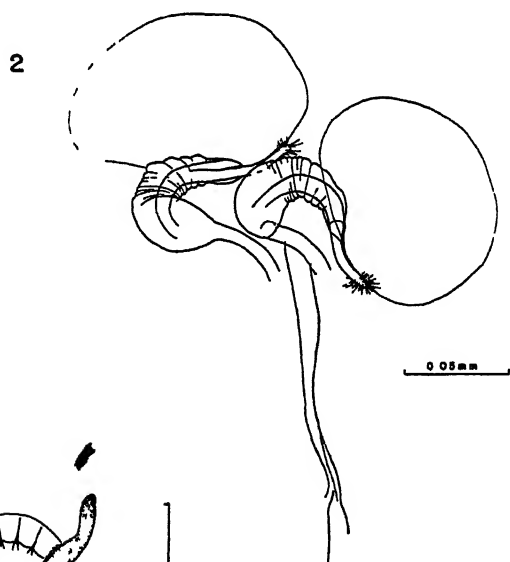
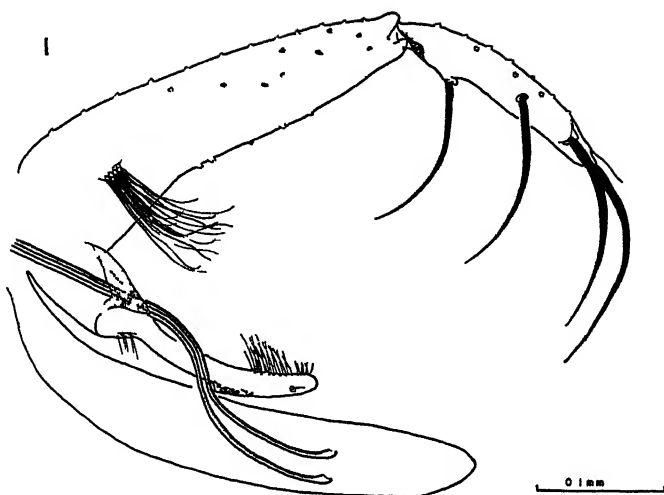
#### Plate III

*Male*.—Genitalia as figured. This species differs most conspicuously from *vesiciferus* and *vespertilionis* in the possession of an additional spine on the style. The parameres have a ventral hook as in *vesiciferus*, not well shown in the figure, but are more slender than in that species. The genital filaments are of the same structure as those of *vesiciferus*, while the lateral lobes are long, as in *vespertilionis*.

*Female*.—Spermatheca and cibarium as figured. Pharynx apparently as in *vespertilionis*. The spermatheca was drawn from the *Allotype* cleared in phenol before mounting. The body of the spermatheca is smaller, the head longer and the inflated portion smaller than in *vesiciferus*, though these differences are hardly perceptible in mounted and shrunken material. The cibarium of our single specimen seems to show the teeth more widely separated and not so deeply set between the posterior arms as in *vesiciferus*.

*Holotype* male, Slide 777, and *allotype* female, Slide 778, Canchacan, Peten, Guatemala, July, 1946, Dr. J. R. de Leon coll. Taken in holes in limestone rock in association with a species of *Nemopalpus*.

The differences between this and *vesiciferus*, with the exception of the style, are slight, and the two are obviously very closely related. Cases such as this indicate the difficulty of attempting to group the species of *Phlebotomus* by means of such obvious genitalic characters as the number of spines on the style.



*Phlebotomus deleoni*. FIG. 1, male genitalia, inner aspect. FIG. 2, spermathecae, from specimen in phenol after KOH and staining. Ducts not further visible. FIG. 3, female cibarium, remainder not clearly visible.

# THE AEDES (FINLAYA) CHRYSOLINEATUS GROUP OF MOSQUITOES (Diptera: Culicidae)<sup>1</sup>

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Lt. Commander, MSC, USN

Edwards (1932) created "Group D (*chrysolineata* group: *Hulecoetomyia*)" for all *Finlaya* species having the following characters: hind tarsi with 3 or more basal white bands, sometimes with apical bands also; femora not lined anteriorly; scutum with distinct narrow longitudinal lines of white or golden scales; and scales of vertex usually mostly narrow. He considered it an Oriental group with an extension into the Australasian region.

An examination of types in the British Museum, in addition to the opportunity to study some new material in the U. S. National Museum, has disclosed additional information on this group.

On the basis of this study, the group has been redefined as follows: (1) Male palpi with segments straight (not swollen or curved), a few hairs present at the apices of the terminal 3 segments, none or very few hairs laterally along the shafts of the apical 2 segments (may be up to about 7 lateral hairs on either side of IV and about 4 on either side of V in a few species), the palpi distinctly shorter than the proboscis (approximately  $\frac{3}{4}$ ths to  $\frac{4}{5}$ ths). (2) Female torus scaled mesally. (3) Scutum with a scale pattern of distinct whitish-yellow or yellow longitudinal lines. (4) Postspiracular area with a patch of scales (confluent with the postspiracular hairs). (5) Fore and mid femora not possessing a complete median longitudinal pale line anteriorly, nor are the tibiae lined anteriorly. (6) Halter knob dark scaled on one side, pale scaled on the other. (7) Hind tarsi with basal bands only, located on the first 3-4 segments (occasionally a few basal pale scales on V in *koreicus*). (8) Oriental in distribution.

The group of species created by this definition has more the characteristics of a "superspecies" than it does of a "group" ("group" as used by Edwards, 1932). However, the use of the term "group" is continued here because of its well-established use in this subgenus.

Since the *chrysolineatus* group is made up of such closely related species, its members have a number of characters in common (in addition to the more basic ones used for the group definition). Consequently, in order to simplify the species descriptions contained in this

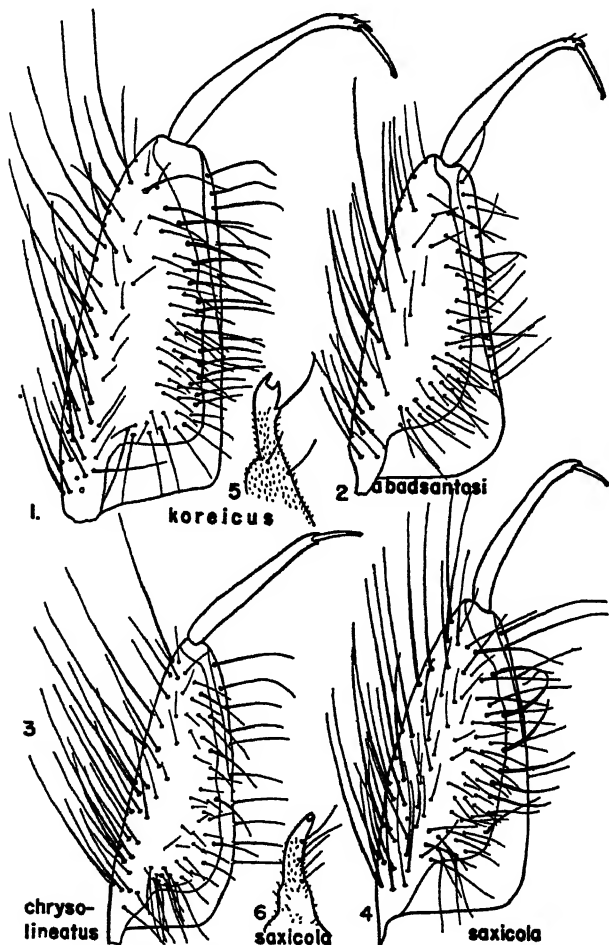
<sup>1</sup>This is the sixth paper of a series prepared in part on collections made in the Philippine Islands under the auspices of U. S. Naval Medical Research Unit No. 2. The work was done in space furnished by the Division of Insects, U. S. National Museum. Additional specimens were made available from the U.S.N.M. through the courtesy of Dr. Alan Stone. Mr. N. D. Riley and Mr. H. Oldroyd gave the fullest assistance in making it possible to examine the types in the British Museum. Mr. R. L. Ingram made the original larval studies for this paper. Mr. F. E. Baisas, Philippine Bureau of Health, very kindly loaned type material for comparison.

paper, these characters are summarized here, and will not be repeated in the descriptions unless subject to variation.

*Male*.—*Head*: Palpus shorter than the proboscis (about  $\frac{3}{4}$ ths to  $\frac{1}{2}$ ths), the segments straight, not noticeably swollen or curved, nearly hairless except for a few bristles at the apices of segments III–V (may also be a very few laterally along the shafts of segments IV–V in some species, up to about 7 lateral hairs on either side of IV and about 4 on either side of V). Vertex with a longitudinal median band of narrow pale scales, this band widened posteriorly into a broad sparse patch, a line of similar scales along the median half of the eye margins; an area of dark scales between the ocular pale line and the posterior patch of narrow pale scales; lateral portion of vertex with broad pale scales, a small anterior patch of dark scales usually visible medially in this area; forked upright scales abundant dorsally from eye margin to nape, pale medially, dusky laterally (sometimes all pale except on submedian dark scaled areas). *Thorax*: Scutal integument brown; covered with small narrow brown and pale (creamy to yellow) scales, the pale scales arranged in full length narrow longitudinal lines as follows: a distinct median line, a submedian line that tends to be broken at the scutal angle (the anterior end of the posterior portion of the line is frequently curved outward along the scutal angle), a line over the wing base (this may be just a diffused area in some species), and a small patch of long narrow curved pale scales just before the wing base. Lateral scutellar lobes with sparse narrow scales, usually dark; mid lobe with broadened flat-lying dark scales laterally, a median longitudinal area of narrower yellowish scales. Pleuron with a patch of broad white scales on each of the following areas: proepisternal (propleural), postspiracular, prealar (below the knob), upper sternopleural, lower-posterior sternopleural, and upper half or more of the mesepimeral (some species also have scales on the paratergite and on the subspiracular region, or on both). Coxae with broad white scales, fore and mid also with dark scales ventrally, and fore usually with some white scales antero-ventrad to the dark scales. Posterior surface of fore femur with a broad dorsal white band from near base to apex (may be interrupted or diminished subapically). Posterior surface of mid femur with basal half largely white, this white continued along the apical half as a ventral band. Anterior surface of hind femur with a broad white area from near base to region of middle, connecting ventrally with a similar area on the posterior surface; dorsal surface usually dark along whole length; apex white beneath, this extending apico-dorsally onto both anterior and posterior surfaces. Tibiae with a baso-ventral white area, this extending laterally a variable amount. Fore and mid tarsal claws unequal, the larger claw with a normal median tooth and a finer acute latero-basal tooth, smaller claw with a subbasal tooth; hind claws equal, simple. Wing dark scaled, nearly always a ventro-basal line of white scales (may be reduced to scattered pale scales) on the costa; 2-3 stout hairs near the base of vein 1. Halter pale, knob with both dark and pale scales. *Abdomen*: Tergite I with lateral margin white scaled, remainder of segments with prominent baso-lateral white spots; usually some dorsal basal pale scaling or even complete basal bands present. Most of the sternites with basal white bands.

*Female*.—In general, similar to the male. Palpus about one-fifth to one-fourth the length of the proboscis. Torus with a patch of broadened scales mesally. Forked upright scales of vertex usually all dark. Tarsal claws equal, fore and mid each with one tooth, hind simple. Dorsal markings of tergites absent, or at least usually more reduced than in male; dorso-lateral markings as in male.

On the basis of this characterization of the *chrysolineatus* group, it is necessary to exclude the following species which were placed there by Edwards (1932): *aureostriatus* (Doleschall), *lauriei* (Carter), *quinque-*



FIGS. 1 (Korea), 2 (Samar, P. Is.), 3 (Bombay), and 4 (Palawan, P. Is.). Inner tergal aspect of basistyle of male genitalia. FIGS. 5 (Korea) and 6 (Palawan). Lateral aspect of basal portion of dissected claspette of male genitalia.

In each case the general geographical locality is given for the specimen from which the drawing was made.

*lineatus* Edwards, *shorti* (Barraud), and *sintoni* (Barraud). Since Edwards' (1932) erection of this group, the following species have been described that belong to it: *abadsantosi* Baisas, *burgosi* Baisas, and *harveyi* var. *nigrorhynchus* Brug. The list of included species now stands as follows: *abadsantosi*, *burgosi*, *chrysolineatus*, *formosensis*, *harveyi*, *h.* var. *nigrorhynchus*, *japonicus*, *jugraensis*, *koreicus*, *pallirostris*, *rizali*, and *saxicola*. In addition, one new species is described in this paper.

In the treatments of species that follow, the distribution records listed from the literature do not include the type localities.

Specimens were examined from the collections of the U. S. National Museum (U. S. N. M.), Academy of Natural Sciences of Philadelphia (A. N. S. P.), British Museum of Natural History (Brit. Mus.), and Cornell University.

#### EXPLANATION OF SYMBOLS

*apn*=anterior pronotum (prothoracic lobe) of adult.

*ppn*=posterior pronotum (proepimeron) of adult.

*lh*=lateral hair of larval anal plate.

*isc*=inner (submedian dorsal) caudal hair of larval anal segment.

#### KEY TO THE ADULTS\*

1. Scutum with median longitudinal pale line not forked posteriorly.....2  
Scutum with median longitudinal pale line forked posteriorly at the prescutellar bare space.....4
2. Hind tarsi with the first four segments with basal white scaling.....*sherki*  
Hind tarsi with only the first three segments with basal white scaling.....3
- 3.<sup>†</sup> Prealar scale patch continuous with the upper sternopleural scale patch,  
*jugraensis*  
Prealar scale patch distinctly separated from the upper sternopleural scale patch.....*abadsantosi*
4. Proboscis all dark scaled.....*burgosi* 5<sup>‡</sup>  
Proboscis with pale scaling present.....7
5. Scutum with median longitudinal line not appearing double; torus of female with dark scales only; mid femora with anterior and antero-dorsal surfaces dark apically.....*saxicola*  
Scutum with median longitudinal line broad, appearing double; torus of female with most of the scales white; mid femora with a dorso-apical white area.....6
6. Hind tarsi with the first three segments basally banded; subspiracular area (area below spiracle along anterior sterno-pleural margin) without scales; *ppn* with some creamy narrow curved scales dorsally (usually numerous broad white scales present elsewhere).....*japonicus*  
Hind tarsi with first four segments basally banded (may be a few basal pale scales on V); subspiracular area with a line of broad white scales; *ppn* with broad white scales (usually a few narrow curved scales also present), *koreicus*
7. Paratergite with a line of broad white scales; subspiracular area with a small patch of broad white scales; prealar scale patch distinctly separated from the upper sternopleural scale patch.....8  
Paratergite and subspiracular areas without scales; prealar scale patch continuous with the upper sternopleural scale patch.....9

\*The males of *h.* var. *nigrorhynchus*, *pallirostris*, and *rizali* are unknown; and no adults of *h.* var. *nigrorhynchus* and *rizali* have been seen during this study.

†Since the type description of *rizali* (Banks) is incomplete on a number of points, it has been impossible to take it beyond this point in the key.

‡From the type description it is impossible to key *h.* var. *nigrorhynchus* beyond this point.



8. Female proboscis mainly pale scaled on all aspects of the basal four-fifths except for a narrow basal dark ring.....*pallirostris*  
Female proboscis with ventral and lateral pale scaling, but without a dorsal pale area.....*formosensis*
9. *Ppn* with many broad white scales; mid femur nearly always with anterior pale scales; female proboscis with ventral pale scaled area broadly produced onto the dorsal surface distad of the middle.....*chrysolineatus*  
*Ppn* with narrow yellowish scales above and some broad white scales posteriorly; mid femur with the anterior surface all dark; female proboscis pale beneath medially, dark laterally and dorsally.....*harveyi*

## KEY TO THE LARVAE\*

1. The apical 2-5 pecten teeth ventrally out of line with the others (fig. 8),  
*shadantsosi*<sup>†</sup>  
*sherkii*
- The apical 2-5 pecten teeth not ventrally out of line with the others (fig. 7)...2
2. At least the anterior comb scales with expanded apices, and each with a rather even apical fringe (fig. 9); (*lh* single).....3  
Comb scales tapered apically, the median apical fringe element noticeably more developed than the others (fig. 7).....5
3. Only the anterior comb scales broad apically, the posterior scales thornlike,  
*formosensis*
- All the comb scales broad apically (fig. 9).....4
4. No simple pecten teeth beyond the base of the siphon hair tuft (fig. 14); anal plate with mostly spiculate scales on the posterior margin.....*koreicus*  
Usually one or more enlarged simple teeth beyond the base of the siphon hair tuft (all the pecten teeth of different type than in *koreicus*, fig. 9); anal plate with mostly simple spines on the posterior margin.....*japonicus*
5. Metathoracic hair 7 with normal slender elongate branching (fig. 13); *lh* with 2 or more branches.....6  
Metathoracic hair 7 with relatively short stout stellate-like barbed branches (fig. 11); *lh* single.....8
6. *Lh* with 3-4 branches.....*chrysolineatus*  
*Lh* double.....7
7. No pecten teeth beyond the base of the siphon hair tuft...*h. var. nigrorhynchus*  
Several pecten teeth between the base of the siphon hair tuft and the apex of the siphon.....*burgosi*
8. No simple (without denticles) pecten teeth apically (and apparently no teeth distad of the siphon hair tuft base).....*jugraensis*  
Two to four simple pecten teeth beyond the base of the siphon hair tuft, and usually one to three simple teeth basad of the hair tuft.....9
9. Mesothoracic hair 1 with 2-4 branches; metathoracic hair 1 with 1-5 branches (fig. 11).....*saxicola*  
Mesothoracic hair 1 with 8-9 branches; metathoracic hair 1 with 11-14 branches.....*Fin. sp., near saxicola*

*Aedes* (*Finlaya*) *saxicola* Edwards, 1922

Figs. 4, 6, 10, 11, 12

1908. *Hulecoeteomyia fluviatilis* Leicester (nec Lutz, 1904), Cul. Malaya, p. 111 (male, female). TYPE-LOC.: Malay Penin. Ulu Gombak (Leicester). TYPE: Non-existent.
1922. *Aedes* (*Finlaya*) *saxicola* Edwards, Ind. Jour. Med. Res. 10: 486 (nom. nov.).
1923. *Finlaya greigi* Barraud, Bull. Ent. Res. 13: 406 (male, female). TYPE-LOC.: Assam. Hailong, Cachar Hills (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.

\*The larvae of *harveyi*, *pallirostris*, and *rizali* are unknown; and no specimens of *chrysolineatus*, *formosensis*, *h. var. nigrorhynchus*, and *jugraensis* have been seen by me.

\*No completely adequate means of separating the larvae of these two species has been discovered.

1932. *A. (F.) saxicola* Edwards, Genera Insectorum, fasc. 194: 151. Synonymy of *greigi*.  
1946. *Aedes (Finlaya) rizali* Banks, Baisas, Phil. Mon. Bull. Bur. Health 22: 21.

ADULT (Description from Philippine specimens). *Male*.—Wing approximately 2.8–3.2 mm. in length. Proboscis all black scaled. Palpus dark, a small basal white area (incomplete dorsally and laterally) on the apical segment. Median scutal line forked at prescutellar bare space. Posterior portion of submedian scutal line broken at the scutal angle, the anterior end of this portion curved outward along the scutal angle for a short distance, this posterior portion of the submedian scutal line is slightly more lateral than the anterior portion. *Apn* with broad creamy scales, some of the dorsal scales narrow; *ppn* with a dorsal and posterior band of narrow yellowish scales, some of the posterior scales may be broader and paler. Anterior surface of fore femur dark except for a pale ventro-basal line; anterior surface of mid femur marked by a median broad white area that begins near the base and tapers apically to a point near the middle (sometimes also a few apical pale scales). Tibiae dark, fore with a pale posterior line that is baso-ventrally broadened onto the anterior surface, mid and hind with a baso-ventral area of white that extends slightly onto the anterior and posterior surfaces. Fore and mid tarsi with narrow basal white rings on I–II, hind tarsus with broad basal bands on I–III, that on III being the widest and occupying the basal two-fifths of the segment (partially broken ventrally by dark scales). Tergites with a small baso-median patch of pale scales on III–VII (may be reduced to just a few scales on some segments), the outer margins of which may join with the baso-lateral white spots on some segments. *Genitalia* (figs. 4 and 6): Basistyle with outer surfaces dark scaled. Claspette stem pilose, with about 5 distinct hairs; claspette blade broadened medially. Ninth tergite lobes divided, with 7–13 hairs on each lobe. Ninth sternite with 2 stout bristles and 1–3 slender hairs (frequently there is a scale associated with these).

*Female*.—Differs from the male chiefly as follows: Wing approximately 3.5 mm. in length. Palpus with a few pale scales apically. Torus with scales all dark. Vertex with the upright-forked scales dark. Fore tibia all dark except for a small baso-ventral white spot. Tergites dorsally dark except for VII–VIII where the baso-lateral white spots extend prominently onto the dorsum, those on VIII sometimes forming a complete band; occasionally a few median basal pale scales present on some of the other tergites.

A small amount of variation was noted. The anterior portion of the scutal submedian line tends to become partially obsolete; the anterior pale area on the mid femur can be greatly reduced, or even missing (this variation was also noted in the Malayan and Indian specimens in the British Museum; the male type of *greigi* has the marking present, whereas it is absent in the female type); and the dorso-basal spots of tergites III–VI (in male) may occasionally form narrow basal bands by connecting laterally with the baso-lateral spots.

LARVA (description from 6 adult-associated skins from Palawan). *Head* (fig. 10): Integument with a fine droplet-like rugosity. Antenna

with scattered spicules; antennal hair inserted approximately at middle, 2-3 branched. Hair 4 very small, with 3-5 branches; 5, 6, and 7 with 4-7; 8, 13, and 14 single; 9 double (rarely single); 12 with 3-5; 15 and 17 with 2-4 (17 once with 5); 18 with 1-3; 20 very small, with 3-5; hairs 4, 5, and 6 very nearly in a straight horizontal line, 7 posterior to this line; hairs 17 and 18 stellate in type. Median mouth brush hairs with prominent comb-like tips. Mentum with 11-14 teeth on either side, the first 3-4 teeth more widely spaced.

*Thorax* (fig. 11): Prothoracic hair 0 very small, with about 15 fine branches; hair 1 with 2-4; 2 single; 3 with 3-5; 13 double. Mesothoracic hair 1 stout, stellate, with 1-4 barbed, elongate branches; 9 large, with 5-6; 10 and 12 stout, elongate, single; hair 11 minute, double, hair 13 minute, with about 12 fine branches. Metathoracic hair 1 stellate, with 1-5 short branches; 7 very stout, stellate, with 3-5 barbed branches; 9 large, with 3; 10 and 11 as on mesothorax, 12 short, slender, single; 13 minute, with about 10 fine branches. The tubercle that arises from the base of the meso- and metathoracic pleural hair tufts with a distinct tapered projection, which however, is shorter in length than the length of the sclerotized base of the hair tufts.

*Abdomen* (fig. 12): Integument with a small amount of very fine unbranched pile posteriorly. Some stellate hairs present. Dorsolateral hair (hair 6) of I and II double, occasionally triple, one branch longer than the others. Lateral hair (hair 7) of I-II single; of III-VI (hair 6) with 1-3 branches (usually double), where 2 or more branches are present one is usually longer. Hair 2 of III-VII stellate, with 1-3 branches. Pentad hair 1 with 1-2 branches, 2 and 4 single, 3 with 7-9 frayed branches, 5 with 2-3 stellate branches. Comb scales in a patch, 55-70 in number, tapered, ending in a stout apical spine, lateral fringe from near base of shaft to apex. Siphon pale yellowish-brown, with transverse striations distinctly visible at 90x; index 2.2 to 2.9; acus present, attached; hair tuft inserted just beyond middle, with 5-7 frayed branches that do not reach the siphon apex; pecten composed of an even line of 12-17 dark teeth that extends nearly to the siphon apex (tip of apical tooth sometimes reaching the siphon apex), each tooth larger than the previous one, 2-4 teeth beyond the base of the siphon hair tuft, these teeth and about the first 1-3 before the hair tuft nearly always simple, the remainder of the teeth with 1-2 ventral denticles. Anal plate incomplete ventrally, with transverse lines of minute spicules, numerous spines along posterior margin; *lh* stout, single, barbed, slightly longer than anal plate; *isc* with 3-5 branches. Ventral brush with 12 tufts, all arising from a conspicuous barred area; each tuft with 3-9 branches. Anal gills slender, tapered rather evenly, dorsal pair slightly longer than the ventral pair and 2.5-3 times longer than the anal plate.

Great variation occurs in this larva in the size of the barbed hairs and in the number of their branches.

*HABITAT.* The larva is commonly found in rock holes and pools in the beds of jungle streams. Causey (1937) collected the larvae from rock pools that were free of visible vegetation and fully exposed to the sun. One record in the U. S. N. M. is from a coconut shell but it seems

possible that this is in error. However, Barraud (1923) reported collecting a larva from a tree hole.

REMARKS. The identification of the Philippine specimens described above is based upon a comparison made in the British Museum with the types of *greigi*, and with some Malayan specimens. According to Edwards (1923), Leicester's types of *fluviatilis* have been lost.

The only possible significant difference noted between the types and the Philippine specimens was that the bases of the wing fork-cells are nearly on a level in the Indian and Malayan specimens, whereas the posterior cell begins definitely nearer to the wing base in the P. I. specimens. The male genitalia agreed well with that of a specimen from Malaya. The larva appears to agree satisfactorily with the published descriptions for *saxicola*.

Baisas (1946) selected a male and female (from Palawan) of this species as novotypes for *rizali*, and described them and the larva and pupa as a redescription for *rizali*.

This species, although nearest to *japonicus* and *koreicus*, more or less stands alone in the group.

DISTRIBUTION. *Specimens examined*. U. S. N. M. (9 males, 8 females, 5 larva, 5 sets of adult-associated larval and pupal skins): *Philippines*. Palawan: (H. Hoogstraal); Irahuan and Balsahan Rivers (D. R. Johnson, J. L. Laffoon, A. T. Fitzjarrell). Brit. Mus. (1 male, 3 females): *Malaya*. Cameron's Highlands, 3500 ft (H. P. Hacker).

*Additional records from the literature*. *Malaya*. Wray's Hill, Pahang (Edwards, 1928); Pulau Oban, Singapore (Edwards and Givens, 1928). *Java*. Mt. Salak (Barraud, 1934). *Siam* (Causey, 1937). *India*. Eastern Himalayas: Kurseong, Darjeeling dist., 5,000 ft. (Barraud, 1934).

### *Aedes* (Finlaya) *japonicus* (Theobald), 1901

Fig. 9

1901. *Culex japonicus* Theobald, Mon. Cul. 1: 385 (female). TYPE-LOC.: Japan. Tokyo (Woods). TYPE: Female (2 cotypes) in Brit. Mus.  
1921. *Aedes* (Finlaya) *eucleptes* Dyar, Insc. Mens. 9: 147 (male and female). TYPE-LOC.: China. Canton (Howard). TYPE: Male (holotype) in U.S.N.M. Male genitalia mounted.  
1922. *Aedes* (Finlaya) *japonicus* Theo. Edwards, Ind. Jour. Med. Res. 10: 465. Synonymy of *eucleptes*.

ADULT. Differs from *saxicola* as follows: *Male*.—Wing approximately 3.5 mm. in length. Palpus all dark. Median scutal line broad, tending to appear double; submedian line double on posterior half, the anterior end of the outer portion bending outward along scutal angle; a broad diffused pale area over wing bases. Lateral scutellar lobes with also a few pale yellow narrow scales (may occasionally be only pale scales on all lobes). *Apn* with an oblique band of broad white scales; *ppn* with yellowish narrow-curved scales anteriorly and dorsally, some of the posterior scales usually broad and whitish, usually a few narrow scales present (the type and distribution of the scales on this area seem to be subject to considerable variation). Mid femur dark anteriorly except for a dorso-apical white area (may be a few pale scales along the median longitudinal line); hind femur with the

median anterior white area usually continuous, at least narrowly, to base (the basal extent of this marking apparently subject to much variation), apical pale area forming a complete ring at apex. *Genitalia*: Arrangement of hairs on the inner tergal surface of the basistyle in general similar to that of *saxicola* (see fig. 4); except that there are fewer stout hairs, about 4, on the inner margin of this surface. Claspette stem pilose, with 3 distinct hairs (generally similar to that of *koreicus*, fig. 5); claspette blade swollen medially (resembling that of *saxicola*). Ninth tergite lobes each with 5-8 hairs. Ninth sternite with about 5 rather equal hairs, none distinctly larger than the others (the type of *eucleptes* has only 2 bristles here).

*Female*.—Wing approximately 3.9 mm. in length. Palpus dark. Torus with white and dark scales present mesally. Scutal pattern similar to that of male except that the inner portion of the posterior half of the submedian line is obsolete.

The extent of the basal pale scaled area on the ventral surface of the costal vein is variable in this species, being reduced to only a few pale scales in some males, and completely missing in the 3 females seen.

*LARVA* (description from 3 larvae from Nagasaki, Kyushu). Similar to *saxicola* in general details but differing chiefly as follows: *Head*: Integument not rugose. *Thorax*: No definitely developed stellate hairs. Prothoracic hair 0 with about 4-7 branches; hair 1 of the meso- and metathorax and hair 7 of the metathorax without noticeable development. *Abdomen* (fig. 9): Integument non-pilose. No definitely developed stellate hairs. Hairs 1 and 2 of segments III-VI slender, single. Comb scales about 45-60 in number, broadened apically and with a rather even lateral and apical fringe. Pecten composed of about 15-22 teeth, 2-3 teeth distinctly beyond the base of the siphon hair tuft, the more apical 1-2 of these simple, the remainder of the teeth beyond the hair tuft and before it with 2-4 serrate denticles each. Posterior margin of anal plate with only a few spines; *lh* single, smooth. Basal 1-2 tufts of ventral brush not arising from the barred area. Anal gills rather broadly lanceolate, approximately 1.5 times longer than the anal plate.

Three larvae from Kyoto, Honshu agreed with the above material except that 2 of the specimens had all the hair tufts of the ventral brush arising from the barred area; and one specimen on one side had only denticulate pecten teeth apically.

One important discrepancy between the above and the published descriptions has been noted. Li and Wu (1935, Hangchow) describe *lh* as being 2-4 branched.

*HABITAT*. The larva has been reported from granite cemetery basins (Edwards, 1921) from clear water in artificial containers near houses in hilly regions, and from hill stream rock holes (Feng, 1938).

Feng (1938) reported that the female bites humans only sparingly.

*REMARKS*. The types of *japonicus* and *eucleptes* have been examined. This species has been commonly confused with *koreicus*, with which it is closely related, but it is well distinct from it on adult and larval characters. Stackleberg (1937) incorrectly ascribes the male genitalic drawing of *koreicus* by Ho (1931) to this species.

According to Yamada (1927), *japonicus* is not a suitable intermediate host of *W. bancrofti*. It has been reported as vector of Japanese encephalitis in the Soviet Far East by Chagin and Kondrat'yev (1943).

**DISTRIBUTION.** Specimens examined. U. S. N. M. (5 males, 3 females, 3 larvae): *Japan*. Honshu: Tokyo (S. Yamada). Kyushu: Nagasaki (D. J. Borror). W. J. LaCasse Coll. (3 females, 3 larvae): *Japan*. Honshu: Kyoto: Otsu (W. J. LaCasse).

*Records from the literature.* *Japan*. Honshu. Shikoku. Kyushu. (Yamada, 1927). *China*. Anhwei: Hwangshan. Chekiang: Hangchow; Hwangyen; Tienmushan; Yetangshan. Fukien: Kushan of Foochow. Kiangsi: Kirikiang. Kwangtung: Canton; Hongkong. (Feng, 1938). Formosa (Hsiao and Bohart, 1946). *Soviet Far East* (Chagin and Kondrat'yev, 1943).

### *Aedes* (Finlaya) *koreicus* (Edwards), 1917

Figs. 1, 5, 14

1917. *Ochlerotatus* (F.) *koreicus* Edwards, Bull. Ent. Res. 7: 212 (male, female).  
TYPE-LOC.: Korea (Mills). TYPE: Male (holotype) in Brit. Mus. Male genitalia mounted.  
1921. *Aedes* (Finlaya) *koreicus* Edw. Edwards, Bull. Ent. Res. 12: 318.  
1930. *Aedes japonicus* Theo. Matheson, Bull. Brooklyn Ent. Soc. 25: 293.  
1931. *Aedes japonicus* Theo. var. *koreicus* Edwards. Ho, Bull. Pan Memorial Instit. Biol. 2: 127.  
1936. *Aedes* (Finlaya) *japonicus* Theobald (= *coreicus* Edw.). Montschadsky, Les Larves des Moustiques de L'URSS et des Pays Limitrophes, p. 301. In part.

**ADULT.** Differs from *saxicola* as follows: *Male*.—Wing approximately 3.4–3.8 mm. in length. Palpus all dark. Upright forked scales dark. Mid scutal line broad, tending to appear double; submedian line broken at level of scutal angle, the anterior end of the posterior portion extending outward along the scutal angle to the scutal margin; a diffused area of pale scales over the wing base. *Apn* with an oblique band of broad white scales; *ppn* with broad white scales, usually some narrow curved scales also present. Subspiracular area (below spiracle along dorso-anterior sternopleural margin) with a line of broad white scales (not noted in type). Fore femur usually with a ventro-apical anterior white spot; mid femur dark anteriorly except for an apical white ring; hind femur with anterior aspect white from base to just beyond middle except for a narrow dorsal line, apex with a complete white band. Fore tibia dark. Fore tarsus with a narrow basal white area on I–II, sometimes a few basal pale scales on III; mid tarsus with rather broader basal white bands on I–III, sometimes a few basal pale scales on IV; hind tarsus with broad basal white bands on I–IV, the band on IV largely broken ventrally, occasionally a few basal pale scales on V. Wing all dark scaled. *Genitalia* (figs. 1 and 5): Inner tergal surface of basistyle bearing fewer hairs than in *saxicola*. Claspette stem pilose, with 3 distinct hairs; claspette blade not particularly swollen medially. Ninth tergite lobes each with about 7–10 hairs. Ninth sternite with 2 large stout bristles and 2–4 slender hairs.

*Female*.—Wing approximately 3.8–5.1 mm. in length. Palpus all dark. Torus with broadened white scales mesally. Costa may have a few baso-ventral white scales.

A small amount of variation was noted in the extent of the white scaling of the legs described above.

**LARVA** (description from 5 larvae from Keijo and Seoul, Korea). Similar to *saxicola* in general details, but differing as follows: Integument of head not rugose. Thorax and abdomen without pilosity or definitely developed stellate hairs. Prothoracic hair 0 with about 4-8 branches; hair 1 of the meso- and metathorax and hair 7 of the metathorax without noticeable development. Lateral hair of abdominal segments I-II with 1-2 branches; of III with 3-4 branches; of IV with 2-3, of V-VI double. Hair 1 of III-VI small, single; hair 2 of III-VI slender, with 1-4 branches. Comb scales about 45-65 in number, broadened apically and with a rather even lateral and apical fringe. Siphon hair tuft (fig. 14) with 6-8 plumose branches; pecten composed of about 24-29 teeth, 0-4 teeth inserted beyond the base of the hair tuft, each tooth with 2-6 serrate ventral denticles. Posterior margin of anal plate with a few spiculate scales and sometimes a very few spines dorsally. Ventral brush with basal 1-2 tufts not arising from the barred area. Anal gills broadly lanceolate, dorsal pair about  $1\frac{1}{2}$  times longer than the anal plate and slightly longer than the ventral pair.

Although this larva has not previously been completely described, Edwards (Barráud, 1934) gave a diagnostic note from Peiping material, and Hsiao and Bohart (1946) figure the terminal segments of a Korean specimen.

**HABITAT.** Ho (1931) stated that this species is one of the common early mosquitoes in Peiping, appearing in the later part of spring. The larva is found in all types of artificial containers about homes, and apparently occasionally even in pools on rocks in the hills (Feng, 1938). Kobayashi (1933) reported that *koreicus* overwinters in the egg stage, hatching in the spring when the ice melts.

The adults will bite humans either day or night.

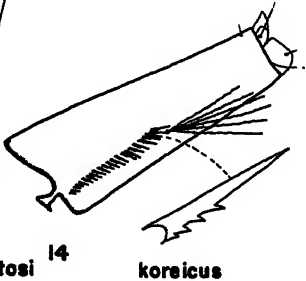
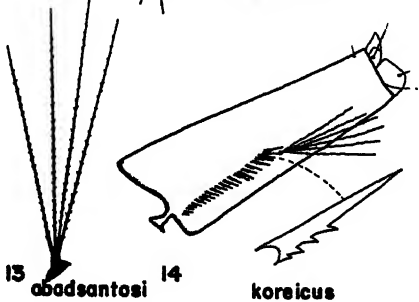
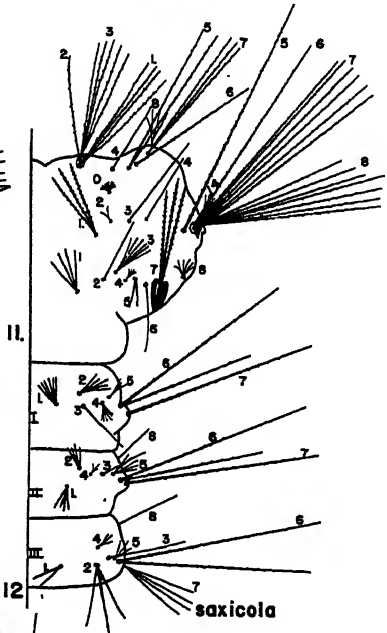
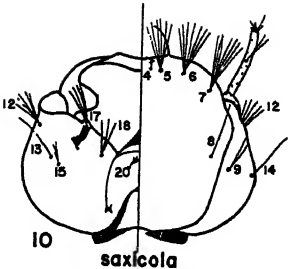
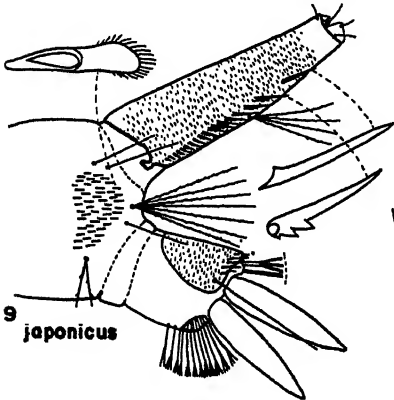
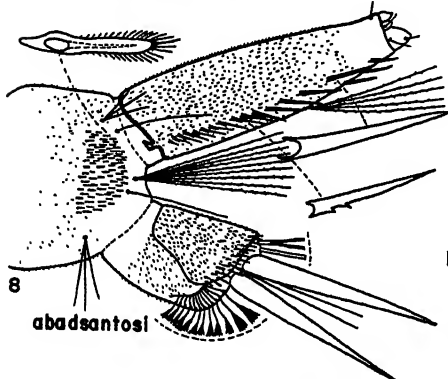
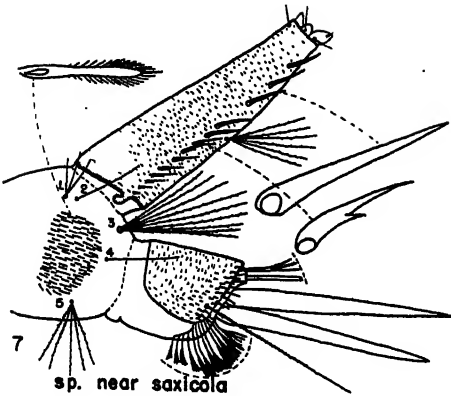
**REMARKS.** The type of *koreicus* has been examined. This species is so closely related to *japonicus* as to have been confused with it by various authors. It is distinct however, on the markings of the hind tarsi, and on the scaling of the subspiracular area.

Yamada (1927) found this species to be an unsuitable intermediate host of *W. bancrofti*. Feng (1938) reported that *koreicus* has been proven experimentally to be a good transmitter of *Dirofilaria immitis* to dogs in Peiping.

**DISTRIBUTION.** *Specimens examined.* U. S. N. M. (14 males, 30 females, 2 larvae): *Korea.* Seoul (E. Pace, I. Preitman, L. Carpelan); Keijo (L. Carpelan). *China.* Hopeh: Peiping (H. E. Meleney). W. J. LaCasse Coll. (3 larvae): *Korea.* Seoul (W. J. LaCasse).

#### EXPLANATION OF PLATE I

FIGS. 7 (Palawan), 8 (Samar), and 9 (Nagasaki, Kyushu). Lateral aspect of larval terminal segments. FIG. 10 (Palawan). Larval head; left half ventral, right half dorsal. FIG. 11 (Palawan). Right dorsal aspect of larval thorax. FIG. 12 (Palawan). Right dorsal aspect of first three abdominal segments. FIG. 13 (Samar). Larval metathoracic hair 7. FIG. 14 (Korea). Lateral aspect of larval siphon.





*Records from the literature: Japan.* Hokkaido (Yamada, 1927). *China.* Hopeh: Pieping. Liaoning: Moukden. Shantung: Tsinan and Taishan (Feng, 1938). *Korea.* Seoul (Matheson, 1930).

***Aedes* (Finlaya) *harveyi* var. *nigrorhynchus* Brug. 1931**

1931. *Aedes* (Finlaya) *harveyi* var. *nigrorhynchus* Brug, Arch. Hydrobiol. Suppl.-Bd. 9: 28 (female, associated larval skin). TYPE-LOC.: Java. Djajasana, Preanger Regentschappen, 1400 m. (Thienemann). TYPE: Female (? holotype), location unknown.

ADULT. Not seen. According to Brug (1931), the female of this species differs from *harveyi* in having the proboscis dark scaled. He stated further that all the males of the collection from which the type female of *nigrorhynchus* came were indistinguishable from the male of *harveyi*. But since Brug apparently had no associated skins for these males, it is impossible to say at present whether or not the male of *nigrorhynchus* is actually inseparable from that of *harveyi*, or whether there simply weren't any male *nigrorhynchus* in the collection. Apparently he had only one larval skin associated with a female with an all dark proboscis. No other adult characters are described by Brug.

LARVA. Brug (1931) stated that the larva of *nigrorhynchus* differs from that of *formosensis* (identified as *harveyi* by him) mainly as follows: antennal hair short, thickened; antennal spicules very small; the comb scales all spinelike, a lateral fringe present; posterior margin of the anal plate with only about 4 spines; *lh* double; and no pecten teeth beyond the siphon hair tuft (Brug's drawing shows at least 1 simple tooth before the hairtuft).

REMARKS. I did not see the type material of this species in the British Museum collection, although Brug stated in the foreword to the article in which *nigrorhynchus* was named, that the types of all species described in the paper were deposited there.

There are no other published records for this species.

Edwards (Barraud, 1934) believed it possible that the larva described by Brug as *nigrorhynchus* may actually be the larva of *harveyi*.

***Aedes* (Finlaya) *chrysolineatus* (Theobald), 1907**

Fig. 3

1904. *Hulecoeteomyia trilineata* Leicester (nec Theobald, 1901), in Theobald, Entom. 27: 163 (male, female. TYPE-LOC.: Malaya. Kuala Lumpur (Leicester). TYPE: Male and female (cotypes) in Brit. Mus. Male genitalia mounted.
1907. *Howardina chrysolineata* Theobald, Mon. Cul. 4: 218 (single female). TYPE-LOC.: Ceylon. Pundabroya<sup>7</sup> (Green). TYPE: Female (holotype) in Brit. Mus.
1910. *Culex* (?) *japonicus* var. *ceylonica* Theobald, Mon. Cul. 5: 391 (2 females). TYPE-LOC.: Ceylon. Peradeniya (Green). TYPE: Female (1 cotype) in Brit. Mus. This species was described but not named in Theobald, Mon. Cul. 3: 158. 1903.
1913. *Stegomyia trilineata* (Leic.). Edwards, Bull. Ent. Res. 4: 226. Synonymized *chrysolineatus* Theobald by comparison of types.
1922. *Aedes* (Finlaya) *chrysolineatus* Theo. Edwards, Ind. Jour. Med. Res. 10: 466. Synonymy of *trilineata* Leicester, 1904.

<sup>7</sup>Barraud (1934) gives this as Pundaluoya.

1923. *Finlaya trilineata* (Leic.). Barraud, Ind. Jour. Med. Res. 11: 500.  
1932. *A. (F.) chrysolineatus* Theobald. Edwards, Genera Insectorum, fasc. 194: 151. Synonymy (questioned) of *japonicus* var. *ceylonica* Theobald. Error in quotation of original species reference for *ceylonica*.

**ADULT.** Closely resembles *saxicola* but differs chiefly as follows:  
**Male.**—Palpi with pale scaling at the joints of III–IV and IV–V, remaining segments dark. Proboscis pale beneath from near base to just beyond middle and also at apex, upper surface dark except for a narrow pale ring just distad of middle. Submedian scutal line with anterior portion complete, more definite. *Apn* with an oblique band of broad white scales; *ppn* with many broad white scales, largely along dorsal and posterior margins. Prealar scale patch continuous with the upper sternopleural patch. Fore femur anteriorly pale along ventral border; mid femur anteriorly dark, or with longitudinal median pale scaling; hind femur more extensively white beneath at tip. Hind tibia more extensively white beneath at base. **Genitalia** (fig. 3): Inner tergal surface of basistyle with arrangement of hairs generally similar to that of *koreicus* (see fig. 1) except that none of the setae immediately along the inner margin of this surface are nearly as broadened and stout as 2–3 of those on *koreicus*, nor are there quite so many setae in the setal band along the inner margin; also the setae along the basal margin of this surface are somewhat clumped so that the impression of a weak basal lobe is given. Claspette stem pilose, 5 distinct hairs present, the apical hair not distinctly longer than the others; claspette blade not widened medially (Barraud, 1934, fig. 37g). Ninth tergite lobes each with about 25 hairs. Ninth sternite with 2 bristles and about 2 hairs, several scales present.

**Female.**—Palpi broadly white-tipped, the exact amount of this white scaling is variable however. Proboscis ventrally pale scaled from near base to beyond middle, and at the apex; the pale scaling broadly produced onto the upper surface just distad of the middle (the dorsal midline may be dark or all pale); the exact amount of pale scaling on the proboscis is subject to considerable variation.

**LARVA.** No specimens of this larva were available for examination, but according to Barraud's (1934) description from Indian material it appears to closely resemble the larva of *saxicola*. The larva of *chrysolineatus* is apparently distinct however, in having metathoracic hair 7 with 6–8 normal branches (as in fig. 13), a comb of 26–30 teeth, *lh* with 3–4 branches, and the apical pecten tooth beyond the hair tuft not reaching near to the apex of the siphon (nor as much enlarged as it is in *saxicola*).

From Borel's (1928, 1930) figure of the larva, it seems possible that he is dealing in part, at least, with another species, for he shows *lh* to be single and the pecten without differentiated teeth beyond the hair tuft.

**HABITAT.** The larva has been reported from tree holes (Barraud, 1923a), from rock holes in a mountain stream (Causey, 1937), from bamboo (Leicester, 1908, and Barraud, 1924), from *Colocasias* (Brug, 1931), and from roof gutters and broken chatti (Barraud, 1934).

Leicester (1908) records the adult as being a sylvan biter.

**REMARKS.** There had previously been no specimens labeled as the

types of *ceylonica* Theobald in the British Museum. However, on request, Mr. P. F. Mattingly, of that institution, very kindly looked through the *chrysolineatus* series and found the October-collected female referred to by Theobald. This specimen is now labeled as a cotype of *ceylonica*. The female collected in June is apparently missing. From a description of the pleural scaling sent by Mr. Mattingly there apparently can be no doubt but that *ceylonica* is a synonym of *chrysolineatus*.

The types of *trilineata* and *chrysolineatus* were examined by me.

DISTRIBUTION. *Specimens examined*. U. S. N. M. (3 males, 3 females): *India*. Bombay: Nagargali and Deccan jungle (P. J. Barraud).

*Records from the literature*. *India*. Bombay: Deccan; Nagargali; North Kanara; Kadra; Yellapur. Malabar: Pudupadi. Eastern Himalayas: Kurseong. Ceylon: Suduganga, Matale Dist. (Barraud, 1934). *Siam*. Patalung Pass (Causey, 1937). *Malaya*: Bukit Kutu and Ulu Gombak, near Kuala Lumpur (Leicester, 1908). *Java*. Ngledok (Brug, 1931); Tosari (Theobald, 1911). *Indochina*. Cochinchina (Borel, 1928).

#### *Aedes* (Finlaya) *harveyi* (Barraud), 1923

1923. *Finlaya harveyi* Barraud, Bull. Ent. Res. 13: 407 (male, female).<sup>1</sup> TYPE-LOC.: India. Eastern Himalayas; Kurseong, Darjeeling dist. (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.  
1931. *Aedes* (Finlaya) *harveyi* (Barr.). Brug. Arch. Hydrobiol. Suppl.-Bd. 9: 26. At least in part *formosensis*.

ADULT. Differs from *saxicola* as follows: *Male*.—Proboscis with a narrow pale ring near middle, complete except for a narrow median dorsal dark line. Palpi with basal pale scaling on IV, a few pale scales between II–III. *Apn* with broad white scales; *ppn* with narrow yellowish scales above and some broad white scales down the posterior margin. Prealar scale patch continuous with the dorsal sternopleural scale patch. Mid femur with anterior surface dark. Tibiae dark except for a small ventro-basal white area. Third hind tarsi segment with basal band occupying slightly over one-half of the segment dorsally. Abdominal tergites with white basal bands. *Genitalia*: Setae of the inner tergal surface of basistyle similar in arrangement and type to those of *abad-santosi* (fig. 2), except that a weak basal lobe is present with some of its setae more or less clumped. Claspette stem pilose, with 3 distinct hairs, the distal one not longer than the others; claspette blade not enlarged medially (Barraud, 1934, fig. 37j), tapered from before middle to apex. Ninth tergite lobes each with 18–24 hairs. Ninth sternite with 2 bristles and 4 short hairs.

*Female*.—Proboscis pale beneath medially, dark laterally and dorsally, the ventral area distad of the pale scaling black, the portion caudad of the marking usually paler. Tergites without dorsal markings.

LARVA. The larva is apparently undescribed. Brug (1931) described a series of larvae from Java, Bali, and Sumatra which he identified as this species. However, Edwards (Barraud, 1934) examined the adults associated with two of the larval skins (from Bali) contained in Brug's series and has pointed out that these are apparently *formosensis*.

Edwards states further that it is possible that the larva described by Brug (1931) as *harveyi* var. *nigrorhynchus* may be the larva of *harveyi*, but that this is not certain. In writing to Brug on this matter, Edwards incorrectly referred the two skins that he had studied to Sumatra. On the basis of this, Brug (1932) stated that the larvae from Sumatra were *formosensis* and those from Java and Bali were *harveyi* and stated that the latter differed from *formosensis* in having the antennal hair tuft before the middle instead of beyond, and in having 2 pecten teeth beyond the siphon hair tuft with one of these near the end of the siphon (instead of just one tooth beyond and it near to the hair tuft). Since Brug made this division on the incorrect information of Edwards, the correct identity of the larva of *harveyi* still remains in doubt.

DISTRIBUTION. *Specimens examined*, U. S. N. M. (1 male, 1 female): India. Eastern Himalayas: Kurseong, Darjeeling dist. (P. J. Barraud).

*Records from the literature*. India. Eastern Himalayas: Kurseong, Mungpoo, Sureil, Tindharia, Sukna, all in Darjeeling dist. Madras: Coonoor. South India: Mercaria, Coorg (Barraud, 1934). Sumatra. Lake Ranau, 700 m., Boekit Daoen (Brug and Edwards, 1931). ? Java. ? Bali. (Brug, 1931).

#### *Aedes* (Finlaya) *formosensis* Yamada, 1921

1921. *Aedes formosensis* Yamada, Annot. Zool. Jap. 10: 67 (female). TYPE-LOC. Formosa. Kakubanzan (Hirayama). TYPE: Female (2 cotypes), location: unknown.

1922. *Aedes formosaensis* Yam. Edwards, Ind. Jour. Med. Res. 10: 262.

1923. *Finlaya khasiana* Barraud, Bull. Ent. Res. 13: 407 (male, female). TYPE-LOC.: Assam. Shillong, Khasi Hills (Barraud). TYPE: Male and female (cotypes) in Brit. Mus.

1931. *Aedes* (Finlaya) *harveyi* (Barr.) Brug, Arch. Hydrobiol. Suppl.-Bd. 9: 26. In part, at least.

1932. *A. (F.) formosensis* Yamada. Edwards, Genera Insectorum, fasc. 194: 151. Synonymy of *khasiana*.

ADULT. Differs from *saxicola* as follows: *Male*.—Proboscis with a ventral and lateral pale area just beyond the middle. Palpus dark, a small basal white area on segments III, IV, and V. *Apn* with broad white scales. Paratergite with a line of broad white scales. Subspiracular area with a small patch of broad white scales. Fore and mid tarsi with narrow basal white rings on I–III; hind tarsus with broad basal bands on I–III, that on III occupying about one-half of the segment. *Genitalia*: The genitalia of this species has not been fully described, nor has a specimen been available for this study. Barraud (1934, fig. 37i) does figure the claspette blade and the ninth sternite, however.

*Female*.—Torus with pale scales medially. Proboscis with the baso-ventral and lateral three-fourths pale scaled, the pale scaling scarcely visible from above.

The above description is based upon an examination of the types of *khasiana*. That this species may not be conspecific with *formosensis* is evident from Yamada's type description in which he describes the female palpus as having a few white scales at the tip of the penultimate segment, in addition to the apical ones; the female proboscis as having only about the middle one-half with lateral and ventral white scales;

the torus bearing a patch of flat black scales; and *apn* with some of the broad scales curved. Final determination of this point must await the examination of the types of *formosensis*. Unfortunately, it is not known on what basis Edwards made this synonymy. The presence or absence of scale patches on the paratergite and on the subspiracular areas will do much to determine whether or not those species are cospecific or not.

**LARVA.** No specimens were available for examination, but according to Edwards' (Barraud, 1934) description of 2 larval skins from Bali, the larva of *formosensis* apparently differs from that of *saxicola* as follows: metathoracic hair 7 with 6-7 long branches (not modified) and arising from a small inconspicuous plate; comb scales 25-40 in number, the anterior ones enlarged apically and apically fringed, the posterior teeth spinelike and with only a lateral fringe; pecten with only about 10 teeth, those basad of the hair tuft with strong basal denticles, only 1-2 (without denticles and not specially produced) beyond the hair tuft; siphon hair tuft with 3 branches; (*lh* single); and *isc* with 2 branches.

The 2 larval skins from Bali described by Edwards are from a series described by Brug (1931) as *harveyi*. However, the adults associated with these 2 skins are *formosensis* according to Edwards. Whether or not the remainder of the series (1 skin from Bali, 16 larvae from Sumatra, and 2 skins and 2 larvae from Java) are also *formosensis*, Edwards was unable to say since he hadn't seen the material.

**HABITAT.** In India, the larva of this species has been collected from bamboo stumps (Barraud). In the Dutch East Indies, it has been collected from the leaf axils of *Colocasia* (Brug). The remainder of Brug's Dutch East Indies collection records are at present not reliable due to a probable confusion with *harveyi*.

Barraud (1924) recorded taking a female in a house at Sureil.

**REMARKS.** As pointed out under the description of the adult, an examination of the types of *khassiana* Barraud showed that it may well be distinct from *formosensis*.

**DISTRIBUTION.** *Records from the literature.* Assam. Shillong; Golaghat; Nongpoh, Khasi Hills dist. India. E. Himalayas: Sureil; Kur-seong (Barraud, 1934). Bali. Batoeriti (Baturiti), Kintamani. Sumatra. Ranau-See. ? Java. (Brug, 1931).

### *Aedes* (Finlaya) *pallirostris* Edwards, 1922

1922. *Aedes* (Finlaya) *pallirostris* Edwards, Ind. Jour. Med. Res. 10: 270 (female). TYPE-LOC.: Assam. Golaghat, Sibsagar dist. (Christophers). TYPE: Female (holotype) in Brit. Mus.

1924. *Finlaya pallirostris* Edw. Barraud, Ind. Jour. Med. Res. 11: 855.

**ADULT.** Differs from *saxicola* mainly as follows: *Male*.—Unknown. *Female*.—Proboscis mainly pale on all aspects of basal four-fifths except for a narrow basal dark ring. *Apn* with broad white scales; *ppn* with narrow curved creamy scales dorsally and some broad creamy scales ventro-posteriorly. Paratergite with a line of broad white scales. Hind femur with some black scales beneath at extreme tip. Tergites II-VII each with a median basal white patch of scales. Sternites with some pale scaling towards hind margins, as well as basally.

**LARVA.** Unknown.

HABITAT. Type reared from bamboo stump.

REMARKS. The type has been examined. This species is very closely related to *formosensis* (Indian material), and Edwards (Barraud, 1934) suggests that it may in fact be just a variation of that species.

DISTRIBUTION. *Records from the literature.* Assam. Nongpoh (Barraud, 1924).

***Aedes* (Finlaya) *abadsantosi* Baisas, 1946**

Figs. 2, 8, 13

1946. *Aedes* (Finlaya) *abadsantosi* Baisas, Phil. Mon. Bull. Bur. Health 22: 25 (male, female, pupa, larva). TYPE-LOC.: Philippines. Luzon Island: Llavac, Infanta Muni., Tayabas Province (Baisas). TYPE: Male (holotype) with assoc. larval and pupal skin mounts, in the Philippine Bureau of Health, Manila.

ADULT. Differs from *saxicola* as follows: *Male*.—Wing approximately 2.5–2.7 mm. in length. Palpus dark, a latero-basal white scaled area on III and IV. Median scutal line extends posteriorly nearly across the prescutellar area, not forked posteriorly, the submedian line is usually broken at the level of the scutal angle (even when not broken a division of the line usually bends briefly antero-laterally along the angle); the line over the wing base anteriorly nearly connects at the scutal angle with the outcurved portion of the submedian line (the extent of the submedian line laterally is variable and it is doubtful whether this constitutes a specific character as stated by Baisas). *Apn* with a few narrowed yellowish scales above, broad creamy scales below; *ppn* sparsely covered with narrow-curved yellowish scales, some of the posterior scales may be broadened, occasionally a few dark scales medially. Mid femur with anterior surface dark (occasionally a few scattered pale scales here). Fore and mid tibiae with a pale posterior line along whole length, a short basal white area anteriorly on the mid tibia, a baso-ventral pale area on the hind tibia. Tergites with complete broad basal white bands on III–VII (that on VII may be narrowed, or even broken, medially). *Genitalia* (fig. 2): Inner tergal surface of basistyle with none of the setae along the inner margin notably enlarged, the setae rather scanty along the apical portion of this margin, the posterior margin of the inner tergal surface not resembling a weak basal lobe (the inner tergal surface of this species greatly resembles that of *harveyi* except for the absence of a weak basal lobe). Claspette stem pilose, 2–3 distinct hairs, the apical hair usually only slightly longer than the others; claspette blade slightly widened medially. Ninth tergite lobes each with 6–10 bristles (Baisas gives 4–8). Ninth sternite with 2 bristles and 1–2 hairs (Baisas gives 2–7).

*Female*.—Wing approximately 2.6–3.1 mm. in length. Mid tibia dark except for a small basal pale area on both the anterior and posterior surfaces. Tergite II dark dorsally, or with a few median basal pale scales; III–VIII with complete basal white bands, occasionally the bands somewhat narrowed medially, and rarely even narrowly incomplete on one or more of any of the segments except VIII.

LARVA (description from 11 associated skins from Samar and Leyte). Differs from *saxicola* chiefly as follows: Integument of head not rugose.

Head hair 15 with 2-3 branches; hairs 17 and 18 (stellate) with 5-7; 20 with 2-3. Thoracic integument heavily pilose (pile simple or branched; Baisas described it as being unbranched). Prominent stellate hairs present. Prothoracic hair 0 small, with 7-11 branches; hair 1 with 4-5; 3 with 5-8; 13 with 3-7. Mesothoracic hair 1 stellate, with 6-10 branches; 13 small, stellate, with 6-12. Metathoracic hair 1 stellate, with 10-13 branches; 7 with 5-9 normal branches (fig. 13). Abdominal integument pilose simple or branched. Many stellate hairs present. Dorso-lateral hair of abdominal segment I and II with 2-3 branches; lateral hair of I-II with 1-2, of III-VI with 2-3. Hair 2 of III-VII elongate, stellate; on III with 5-6 branches; on IV and V with 3-5; on VI and VII with 2-4. Comb scales 50-72 in number (fig. 8); broad and scalelike, not appreciably tapered apically, with a conspicuous uneven lateral and apical fringe, a medial heavier spicule nearly always apparent. Siphon pilose (quite distinct at 90x; hair tuft with 4-5 long branches, the tips extending beyond the siphon apex; pecten composed of 15-20 long teeth, each tooth larger than the previous one, 4-6 teeth beyond the siphon hair tuft, the apical 4-7 teeth simple, the remainder each with 1-3 ventral denticles, the apical 2-5 teeth out of line with the others, tip of apical tooth approximately on a level with siphon apex (usually is hard to see the ventral denticles unless siphon is strongly flattened). Anal plate pilose; *lh* with 2 equal branches (rarely 3).

The larvae of specimens from Mindanao (all from one larval collection; 8 associated skins examined) differed slightly from those described above in having the tubercle of the meso- and metathoracic pleural hair tufts slenderer, and fully as long as the sclerotized base of the hair tuft. Also, the apical pecten tooth nearly always extends one-fourth to one-half its length beyond the end of the siphon, and all the pecten teeth except the apical ones that are out of line possess ventral denticles, these denticles are more prominent, and sometimes a small one occurs distad to the large one.

Considerable variation occurs in this larva, particularly in regards to the size and number of the branches of the stellate hairs, and in the amount and number of branches of the pile.

PUPA. Briefly described by Baisas (1946).

HABITAT. The larva is commonly found in the water collected in rock holes in and along the stream beds of forested streams. The rock pools may be small or large, and in shade or sun. Two records were taken of the larvae occurring in hollows on roots or fallen logs along stream beds. Collections of this species were made in all of the months from January to September.

REMARKS. The type series (exclusive of the adult of the holotype; the male genitalia was included however) was kindly loaned to the U. S. N. M. by Mr. Baisas for my examination. Unfortunately, all of the adult specimens were destroyed in transit. However, the male genitalia and the larval and pupal skins of the type series were undamaged, and with these the material described here compares well except that the anal gills of the types are somewhat shorter and more rounded apically.

Some variation was noted in the material studied. The color of the

upright forked scales of the female varied occasionally, being sometimes either mixed dark and pale, or nearly all pale. The submedian scutal lines are occasionally unbroken on one or both sides. Occasionally, the outwardly curved portion of the submedian line and the anterior end of the lateral line meet, as described by Banks for *rizali*. In several female specimens from Mindanao, a few median pale scales were seen on the palpi as described for *rizali*. Only once was a female specimen (from Samar) seen in which all of the abdominal tergite bands, except VIII, were medially broken, and these were only narrowly so. Female specimens from Leyte and Samar were quite uniform in having well-developed white basal bands on the tergites, whereas those from Mindanao generally had these bands reduced and occasionally even broken.

**DISTRIBUTION.** Known only from the Philippines. *Specimens examined*, U. S. N. M. (10 males, 32 females, 39 sets of adult-associated larval and pupal skins): Samar: Osmena (Lat. 11° 11.7', Long. 125° 11.3'); Sohoton Springs, on Basey River. Mindanao: San Ramon, Zamboanga Province (J. L. Laffoon, L. E. Rozeboom, D. R. Johnson, E. S. Zolik, K. L. Knight). A. N. S. P. (10 males, 21 females, 9 larvae, 3 sets of assoc. larval and pupal skins): Leyte: Lagolago (near Baybay), Dagami (mt. stream), Samar: Osmena (H. R. Roberts).

*Records from the literature.* Luzon: Upper Molawin Creek, Los Banos Agr. Coll., Laguna Province (Baisas, 1946).

### *Aedes* (Finlaya) *burgosi* Baisas, 1946

1946. *Aedes* (Finlaya) *burgosi* Baisas, Phil. Mon. Bull. Bur. Health 22: 27 (males, females, larvae, pupae). TYPE-LOC.: Philippines. Mindanao Island: Titunod Creek in Kolambugan, Lanao\* (Guinto). TYPE: Male (holotype), non-existent. Paratypes in the Philippine Bureau of Science and in the U.S.N.M.

**ADULT.** Mr. Baisas kindly made a loan of the holotype (the genitalia mount was not included, however), allotype, 5 paratypes, 1 male genitalia mount (of a paratype), and 2 larvae to the U. S. N. M. for use in this study. Unfortunately all of the adult specimens (except the thoracic capsule of 2 paratypes) were destroyed in transit.

From the type description and from an examination of the thorax of the 2 paratypes, this species is not separable from *abadsantosi* on adult external characters. The male genitalia differ, however, in having 12-30 bristles on each lobe of the ninth tergite. The ninth sternite usually bears only 2 bristles. In all other characters the genitalia are apparently identical with those of *abadsantosi*.

The 2 larval specimens sent by Mr. Baisas differ in several respects from the larva of *abadsantosi*; and also, are somewhat different from one another. One larva (R112-m) has the following distinctive characters from *abadsantosi*: head hair 17 with 6-9 branches; hair 18 with 5-6; mesothoracic hair 1 with 11; metathoracic hair 1 with 14-16; hair 2 of abdominal segment III with 7-9, of IV with 5-7, of V with 5, and of VI with 5; pentad hair 1 with 6, and 5 with 5; and the pecten teeth all in a

\*Titunod Creek, Kolambugan, is given by the Gazetteer to Maps of the Philippine Islands, July, 1944, 2d Ed. (Army Map Service, U. S. War Dept.) as being in Misamis Occidental Province, Mindanao, which is some distance removed from Lanao.



line. The other larva (R112-k) differs as follows: head hair 17 with 8-11 branches; hair 18 with 7-9; mesothoracic hair 1 with 13-15; metathoracic hair 1 with 21; hair 2 of abdominal segment III with 11, of IV with 9, of V with 9-10, and of VI with 9; pentad hair 1 with 11, and 5 with 6; comb teeth longer and slenderer, a long distinct apical spine, and all of the fringe elements lateral; the teeth along the posterior margin of the anal plate very long; and, all of the pecten teeth in line except the last 2, which are dorsad to the line.

Whether or not the 2 larvae described above are conspecific will have to await the study of associated material. Until such material is available the larva of *burgosi* is considered to differ from *abadsantosi* on the greater number of branches of some of the hairs, and on the pecten not having any of the teeth distinctly out of line ventrally.

Baisas (1946) considered a series of specimens with associated larval and pupal skins from Mt. Apo, Davao, Mindanao (H. Hoogstraal) to be *burgosi*. The male genitalia (2 males) of these differed from the type series of *burgosi*, however, in having only 9-11 bristles on each lobe of the ninth tergite and in having 3 bristles on the ninth sternite (a scale was also present here in one specimen). I have not seen the larvae of this series, so cannot say how they compare with the 2 specimens of the type series described above.

If the Mt. Apo series is considered to be *burgosi*, the range of the number of hairs occurring on the ninth tergite will be enlarged sufficiently (9-30) so as to overlap the range for *abadsantosi* (4-10), thus making the distinction between them on this character of dubious value.

PUPA. Described by Baisas (1946) from specimens of the Mt. Apo series.

DISTRIBUTION. Known definitely only from the type series.

### *Aedes* (Finlaya) *rizali* (Banks), 1906

1906. *Culex rizali* Banks, Phil. Jour. Sci. 1: 999 (2 females). TYPE-LOC.: Philippines. Negros Island: Volcano Canlaon, Mt. Siya-Siya, at altitude of 760 meters, Negros Occidental Province (Banks). TYPE: Female (holotype), formerly was in Ent. Coll., Bur. Sci., Manila; now destroyed.
1922. *Aedes* (Finlaya) *rizali* Banks. Edwards, Ind. Jour. Med. Res. 10: 466.

ADULT. Not seen. By reference to the type description, this species apparently differs from *saxicola* as follows: *Male*.—Unknown. *Female*.—Wing 4 mm. in length. *Apn* with a small oblong patch of golden-yellow scales (no reference made in description to *ppn* or to the scaling of the pleuron). Median scutal line extending halfway across the prescutellar bare space, not forked posteriorly; the submedian line broken at the scutal angle and connecting laterally with the line over the wing base. Tergites dorsally dark except for VI-VIII where the baso-lateral white spots extent slightly onto the margin of the dorsum. Banks described the pale areas of the femora as being "golden-brown," as opposed to the dark portions which he called "dark-brown"; however, the location of these paler areas coincides with the femoral white areas of *saxicola*. The tibiae are described as being all dark.

LARVA. Unknown.

**HABITAT.** The two females that made up the type series were taken in the act of biting.

**REMARKS.** This species has apparently not been retaken since Banks' type series was collected, nor have any additional notes ever been published on the type. Baisas (1946) states that the types of *rizali* were destroyed during the war.

This species is undoubtedly very closely related to *abadsantosi* and *burgosi*, the only significant difference apparent from the type descriptions being the complete or nearly complete tergal bands of the latter two (always complete on VIII). The extent of the tergal markings is subject to so much variation in the *chrysolineatus* group that it is even possible that this character does not offer a valid distinction. Consequently, until material is again collected from the type locality of *rizali* its exact status will probably remain undetermined. With only the type description to go on, it is also not separable from *jugraensis*.

I have examined the novotype material (only male genitalia and larval and pupal skins, as the adults were destroyed in shipment) designated for *rizali* by Baisas (1946), and it is conspecific with the species treated in this paper as *saxicola*.

#### ***Aedes* (Finlaya) *sherki*, new species**

**ADULT.** Similar to *saxicola*, but differing chiefly as follows: *Male*.—Wing approximately 2.7–3.4 mm. in length. Palpus dark, a few pale scales over the joint between III–IV. Median scutal line extends posteriorly nearly across the prescutellar area, not forked posteriorly; the submedian line is usually broken at the level of the scutal angle (even when not broken a division of the line usually bends briefly antero-laterally along the angle); the line over the wing base anteriorly nearly connecting at the scutal angle with the outcurved portion of the submedian line. *Apn* with a few narrowed yellowish scales above, broad creamy below; *ppn* sparsely covered with narrow-curved yellowish scales, some of the posterior scales may be broadened. Anterior surface of mid femur dark. Fore and mid tibiae with a pale posterior line along whole length, a short basal white area anteriorly on the mid tibia, a baso-ventral pale area on the hind tibia. Fore and mid tarsi sometimes with a small basal patch of white scales on III; hind tarsus with the first four segments basally banded. Tergites with complete broad basal white bands on III–VII, sometimes the bands narrowed dorsally, and with the dorsal portion separated from the dorso-lateral spot on III. *Genitalia*: Apparently identical to that of *abadsantosi* (see fig. 2) except that the ninth tergite lobes each bear 11–14 bristles.

*Female*.—Palpus with apex ringed with white scales. Tergites II–VI dark dorsally, or with a small medio-basal creamy patch on one or more of the segments, VII with the baso-lateral white spots extending prominently onto the dorsum; VIII with a complete basal white band.

**LARVA.** This larva is apparently not distinguishable from that of *abadsantosi* (see figs. 8 and 13). As with that species, considerable variation occurs in the size and the number of branches of the hairs, and in the amount of pilosity.

The six specimens from the collection containing the holotype (L. E. Rozeboom) are closely similar to that of the *abadsantosi* material from Leyte-Samar, except that the body pilosity is not as prominent and the pile on the siphon is hardly visible at 90x. Also, in most of the specimens the pecten teeth are somewhat smaller, with the apical tooth extending distinctly beyond the siphon apex.

The remainder of the larval specimens are similar to the Leyte-Samar *abadsantosi* material in having the body pilosity heavy and that on the siphon noticeably distinct at 90x, but differ in having the siphon and anal plate darkly pigmented, the pecten teeth with prominent and numerous denticles (usually first 2 teeth distad of hair tuft each with a denticle) and in having the apical pecten tooth usually extending distinctly beyond the siphon apex.

Only one specimen of the larval series for *sherki* exhibited sufficient production of the meso- and metathoracic hair tuft tubercle to be confused with the larval series of *abadsantosi* from Mindanao.

**TYPES.** *Holotype:* Male (1162.4) with associated larval and pupal skins (U. S. N. M. Cat. 58370), Baguio, City of Baguio Province, Luzon Island, Philippines, August 10, 1945 (L. E. Rozeboom, reared from small rock pool in rocky cool stream. *Paratypes:* Four males, 5 females 5 sets of associated larval and pupal skins, same data as for holotype; 2 females, Baguio, Luzon, June 12, 1945 (K. V. Krombein), reared from rock pool; 5 males, 14 females, 5 larval skins, Baguio, Luzon, August-September, 1945 (S. E. Shields), reared from a cardboard container, a can, and a rock pool; 2 males, 2 females, Baguio, Luzon, May, 1945 (A. B. Gurney and S. Soltys), from a forest stream; 10 males, 10 females, Park Circle, Baguio, Luzon, May, 1945 (J. C. Franclemont), from rock hole containing pine needles.

The series collected by Mr. Franclemont contains, in addition to the paratypes, 38 adults and 12 larva (Cornell University Collection).

Paratypes are deposited in the U. S. N. M., Academy of Natural Sciences of Philadelphia, British Museum (Natural History), Cornell University, and the Philippine Bureau of Health.

**REMARKS.** The adult of this species differs from all the other members of this group in having the combination of a basal white patch or band on segment IV of the hind tarsi, and in having the mid scutal line unforked posteriorly.

The two types of larvae described are probably only natural variant forms. No definite character for the separation of the larva of *abadsantosi* and the larva of this species was found. All characters examined seemed to show sufficient intergradation to render them useless for positive identification. It is true that the apical pecten tooth in *sherki* generally exceeds the siphon apex by one-fourth to one-half of its length, whereas it rarely does so in *abadsantosi*.

This species is dedicated to Sgt. Herman D. Sherk, a tireless collector in the 423rd Malaria Survey Unit, who aided Dr. A. B. Gurney in making a large collection of Pacific mosquitoes.

*Aedes* (Finlaya) *jugraensis* (Leicester), 1908

1908. *Helecoctemyia jugraensis* Leicester, Cul. Malaya, p. 109 (male, female).  
TYPE-LOC.: Malaya. Jugra (Leicester). TYPE: Male, female, (cotypes),  
not in existence.

1922. *Aedes* (Finlaya) *jugraensis* Leicester. Edwards, Ind. Jour. Med. Res.  
10: 466.

ADULT. Differs from *saxicola* as follows: *Male*.—Median scutal line extends onto the prescutellar bare space, nor forked posteriorly; anterior portion of submedian line absent or represented only by scattered scales. *Apn* with broad white scales; *ppn* with narrow scales. Prealar scale patch continuous with the dorsal sternopleural scale patch. Fore femur with a small creamy patch on the upper surface of the apex (this is according to Leicester; I failed to check this on the specimens). Tergites with the baso-lateral spots extended onto the dorsum and nearly forming complete bands on some segments. *Genitalia*: No information.

*Female*.—Whether or not the torus is scaled was unfortunately not noted. Tergites dark dorsally.

LARVA. No specimens have been seen, but from the description by Edwards and Givens (1928) and Edwards (Barraud, 1934) it apparently differs from *saxicola* as follows: Antenna with a small 2-branched hair placed a little beyond the middle. The base of the meso- and metathoracic pleural hair tufts each with a "rather long spine." (Metathoracic hair 7 as in *saxicola*). Abdominal lateral hairs triple on III-V, double on VI. Comb consisting of a patch of about 20 simple sharp-pointed teeth. Siphon index rather under 2. Pecten of 12-14 teeth, each with one large and several small denticles, the teeth forming a regular close-set row extending half the length of the siphon, no simple teeth apically (no mention is made whether there are any pecten teeth beyond the siphon hair tuft). (*lh* single).

HABITAT. The larva has been collected in fallen forest leaves, where it has been found in association with *Zeugnomys gracilis* Leicester and *Uranotaenia obscura* Edwards (Edwards and Givens, 1928).

REMARKS. I was unable to find the type of this species in the British Museum, and since according to Mr. J. A. Reid, Institute for Medical Research, Kuala Lumpur, Malaya (in personal communication) there are no Leicester types at Kuala Lumpur, the types are apparently non-existent.

With present information, the adult of *jugraensis* cannot be separated from that of *rizali*.

DISTRIBUTION. *Specimens examined*, Brit. Mus. (1 male, 5 females): *Malaya*. Singapore, Ulu Gombak.

*Aedes* (Finlaya) sp., near *saxicola*

## Fig. 7

There are four larval specimens from Palawan Island, Philippines in the U. S. N. M., that represent a previously unrecorded Philippine species. The larva is closely related to that of *saxicola* and is accordingly included here. Three of these specimens were collected (Oct.,

1945) from a streambed boulder depression and were submitted by Capt. Harry Hoogstraal of the 19th Medical General Laboratory—U. S. Army). The other specimen was collected in a rock hole on the Balsahan River (June, 1945) by J. L. Laffoon.

**LARVA** (fig. 7). Similar to *saxicola*, but differing chiefly as follows: Head hair 17 with 5–8 branches; 18 with 3–4. Prothoracic 0 hair larger, stellate; hair 1 with 4–7 branches; hair 3 with 7–9. Mesothoracic hair 1 with 8–9 branches; hair 13 a large stellate tuft of about 13–22 slender long frayed branches. Metathoracic hair 1 with 11–14 branches; hair 13 a large stellate tuft of about 12 slender long frayed branches. Abdominal integument finely pilose. Prominent stellate hairs present on all segments (particularly hairs 1 and 2). Dorso-lateral hair of I–II with 3–4 branches; lateral hair of I–II with 2–3 branches, of III–VI with 3–4—occasionally 2). Hair 2 of III–VI stellate, with 4–6 elongate branches. Pentad hair 1 with 2–5 branches, 3 with 8–10, 5 with 4–5.

**REMARKS.** The differences between this larva and that of *saxicola* apparently consist entirely of the possession of more heavily branched hairs. Although these differences are very great, there are apparently no real structural differences. Consequently, this larva may represent only a form of *saxicola*, rather than a new species.

#### *Aedes* spp., near *abadsantosi*

In the British Museum collection there is a female specimen from the Philippines that possibly represents an unknown species. It closely resembles *abadsantosi* except that the anterior portion of the postspiracular scale patch consists of narrow yellowish scales and does not extend to the ventral margin of the spiracle. All of the abdominal tergites are dorsally dark except for a complete basal band on VIII. The specimen has the following data: Mt. Mupo, Dansalan (Mindanao); 28. III. 1920 (Dr. A. Moore).

In the collection of the Acad. of Natural Sciences of Philadelphia, there is a female specimen, Lagolago, Leyte (H. R. Roberts), with the postspiracular scales similar to those of the above specimen but differing in having the tergites with complete basal bands.

Also, in the U. S. National Museum there is a male specimen, with associated larval and pupal skins, which cannot be separated from *abadsantosi* except on male genitalic characters. The claspette blade is slender and tubular instead of being laterally flattened (this is utterly unlike anything known in this group), and there are 11–13 hairs on each of the ninth tergite lobes. This specimen must represent a distinct species but because of the lack of material, it is not named here. The data for this specimen is: San Ramon, Mindanao (K. L. Knight and J. L. Lafoon), reared from rock hole in hill stream, Sept. 17, 1945.

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A GENERIC REVISION OF THE ICHNEUMON-FLIES OF THE TRIBE OPHIONINI, by R. A. CUSHMAN. Proceedings of the United States National Museum, Vol. 96, No. 3206, pages 417-482, plates 49-56, 1947.

The author indicates in his opening paragraph that a projected revision of *Ophion* disclosed inconsistencies of the older classification which necessitated a wider study of the tribe and led to the present generic revision. During his study he found a number of characters not previously employed, hence we may conclude that his revised classification represents a more thorough analysis of the group and a more dependable and practical arrangement than has previously been available. It is unfortunate that material of all genera was not available, but this is a limitation that must often be faced in dealing with such widespread groups of insects.

The article includes a key to the tribes of Ophioninae and a key to the genera of Ophionini. Some new combinations are established and several new genera and species are described but the species making up the various genera are not treated in full—in short, the title "Generic Revision" is accurate. The plates are made up of excellent drawings of structural details. While the article will be of little practical value for the identification of specimens it is an important contribution to the basic classification of the insects.—A. W. L.

A NEW GENUS AND SPECIES OF PSYLLIDAE  
FROM MEXICO  
(Homoptera)

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In 1913<sup>1</sup> Crawford erected the genus *Paurocephala* for the Philippine species *psylloptera*, and later in 1914<sup>2</sup> described *magnifrons* a Mexican species in this genus. In 1919<sup>3</sup> after describing *Paurocephala conigra* from the Molaccas Crawford states that *conigra* is closely related to *magnifrons* and intimates that the two forms possibly constitute a new genus. I am not familiar with *conigra* and have not included it in this work. The genus *Trigonon* Crawford was set up in 1920<sup>4</sup> to receive two South Pacific forms, the type *Heteropsylla longicornis* Crawf. and *T. pacificum* Crawf. Subsequently in 1925<sup>5</sup> *Psylla erythrinae* Lizer, a South American species, was placed in *Trigonon*. There is no doubt that *magnifrons* Crawf. and *erythrinae* Lizer are congeneric even though each have been placed in separate genera.

I have examined specimens of *longicornis* and *pacificum* Crawford, loaned to me through the courtesy of the proper authorities of the U. S. National Museum upon the recommendation of Miss Louise M. Russell of the U. S. Department of Agriculture, and find *longicornis* to be generically distinct from *erythrinae* and *magnifrons*; nor can these two American species be included in *Paurocephala* as represented by the type species. The forms in the Western Hemisphere, with one exception, are without a genus consequently I propose a new genus to include *magnifrons* Crawford and *erythrinae* Lizer, and a new species from Mexico. This leaves *Paurocephala fremontiae* Klyver the dubious representative of *Paurocephala* in the new world.

**Neopsyllia** new gen.

Head broader than thorax. Vertex twice as broad as long, evenly rounded downward and under, narrowed to a prominent frons. Eyes prominent; lateral ocelli scarcely elevated above plane of vertex. Clypeus rounded, prominent. Genae greatly swollen. Antennae about as long as entire insect. Thorax little arched; pronotum declivent. Forewings elongate; basal costal margin thin, plate-like; pterostigma long, narrow; first marginal cell approximately twice the size of second. Apex of hind tibiae with one spur on out side and four within, two of the four closely appressed. Proctiger of male without caudal flaps.

Differing from either *Trigonon* Crawf. or *Paurocephala* Crawf. by the broad, very smooth vertex narrowed and evenly rounded to the

<sup>1</sup>1913. Philip. Jr. Sci., 8: 293-294.

<sup>2</sup>1914. U. S. N. M. Bul. 35: 42-43.

<sup>3</sup>1919. Philip. Jr. Sci., 15: 151-152.

<sup>4</sup>1920. Philip. Jr. Sci., 17: 354-355.

<sup>5</sup>1925. Broteria Ser. Zoo., 22: 18-19.

frons. Separated from *Heteropsylla* Crawf. by the vertex, frons, and genae forming a smooth surface and by the frons being placed before the genae. The forewings also lack the very broad pterostigma characteristic of *Heteropsylla*.

Type: *Neopsyllia amabilis* n. sp.

***Neopsyllia amabilis* n. sp.**

Total length of male 3.4 mm., female 3.9 mm.; forewing of male 2.8 mm., female 3.1 mm. Face orange-yellow with a transverse black stripe between eyes. Antennae yellow on four basal segments, remainder black. Pronotum marked with black as follows; a median dash on anterior margin and a transverse line near posterior margin interrupted medially. Prescutum with a black median line and an ovate mark on either side of the line. Scutum sometimes with a broad orange stripe far latrad on either side. Abdomen yellow; tergites margined and spotted with black; an irregular black line present on either side in ventral aspect. Forewings hyaline, slightly yellowed apically; four indistinct dark marginal dashes present apically.

Proctiger of male quadrate in lateral aspect. Genital capsule broadly notched on ventro-anterior margin. Forceps as long as proctiger, broad; apices narrow, convergent, each terminated by a blunt tooth; apical third of anterior margins bearing very heavy spines. Female genital segment as long as rest of abdomen; dorsal valve narrowed in apical third to styliiform apex.

Male *holotype*, five male and five female *paratypes* from Jalapa, Veracruz, 10-31-45, K. 270, (DeLong, Elliott, Hershberger, & Shaw). Female *allotype* from Jacala, Hidalgo, 8-13-36, (Ball) is in the U. S. National Museum. I have also seen one female in poor condition intercepted by the Bureau of Entomology & Plant Quarantine with the following date: 2-4-47, Chilpancingo, Guerrero.

**A PLEA FOR BREVITY—AND SANITY—IN ZOOLOGICAL NOMENCLATURE**, by J. C. FAURE. *Journal of the Entomological Society of South Africa*, Vol. IX, pp. 39-44, 1946.

This short article, which has reached the editor as an author's reprint, brings up the perennial difficulty of unwieldy scientific names. *Brachyuropushkydermatogammarus* remains in the reviewer's memory from years ago as a gem to be ridiculed before his classes, but the author cites other such names from the work of Dybowski, published in 1926, as a basis for his very lucid plea for practical limitations on the coining of scientific names. One is forced to agree with him that descriptiveness is of little if any value in our scientific nomenclature; certainly an adequate description cannot be encompassed by one word, whatever its length. Shortness and pronounceability, appropriateness and descriptiveness as far as the latter is possible, and sufficient difference from existing names to avoid confusion are the principal points emphasized. The author suggests that it may be wise for the International Rules to contain a limitation of fifteen letters for newly proposed scientific names. Probably the good sense of most taxonomists makes a rule unnecessary, but workers on the Crustacea who may run afoul of Dybowski's creations may find it desirable.—A. W. L.



# SPORADIC POLYEMBRYONY IN GRASSHOPPER EGGS

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and the  
Hebrew University, Jerusalem, Palestine

The finding of more than one embryo in a grasshopper egg is a rare event (Evans, 1937) and when, through correspondence, it was discovered that the authors of the present paper had both found eggs which contained extra embryos it was decided to combine the results in a single report.

The eggs of *Dociostaurus maroccanus* were obtained and studied by Shulow in Palestine and those of *Melanoplus differentialis* were secured from the grasshopper colony maintained in the Zoology Department at the State University of Iowa and were examined by Slifer.

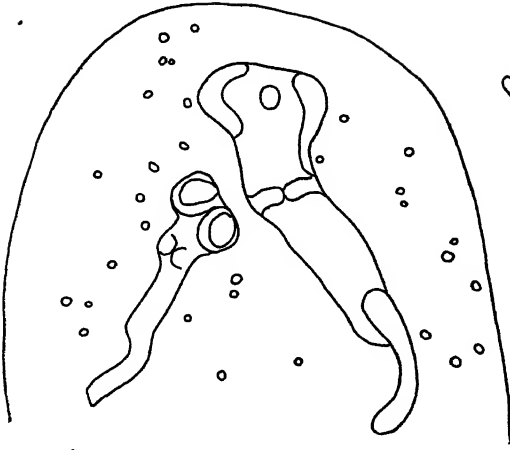
## *Dociostaurus maroccanus*

During extensive investigations (Bodenheimer and Shulow) on the eggs of *Dociostaurus maroccanus* two were found which contained more than one embryo. Externally these eggs were normal in size and shape and the unusual internal conditions were discovered only after the eggs had been fixed and then stained with borax carmine. In this respect the eggs differed from those of *Carausius morosus*, *Menexenus semiarmatus*, *Baculum (Clitumnus) artemis* and *Clonopsis gallica* described by Cappe de Baillon (1927, 1928, 1937). In these phasmid eggs with twin embryos the micropylar apparatus on the chorion was double and the operculum, which is ordinarily present, was missing.

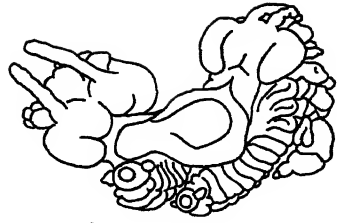
The normal embryology of *Dociostaurus maroccanus* is essentially like that of *Melanoplus* (Slifer, 1932) and *Locusta* (Roonwal, 1937). The early germ band is a flattened structure, pear-shaped in outline, and is located close to the posterior or micropylar end of the egg. The caudal end of the embryo broadens and grows in length while the protocephalic region increases in size. This is followed by segmentation and the appearance of the appendages. During these stages the

## EXPLANATION OF PLATE I

FIG. 1. *Dociostaurus maroccanus*. Posterior end of egg with three embryos. The cephalic end of each embryo faces the micropylar end of the egg. Largest embryo 0.65 mm. in length. FIG. 2. *Dociostaurus maroccanus*. Two embryos from one egg. Total length of both embryos 0.43 mm. FIG. 3. *Melanoplus differentialis*. Twin male embryos from one egg. Before removal from egg dorsal surfaces were in closer contact and heads and abdomens were not flexed backwards. Length of embryos about 2 mm. FIG. 4. Same embryos as Fig. 3, opposite surface. FIG. 5. *Melanoplus differentialis*. Twin embryos from one egg. Larger embryo apparently a female, sex of other not determined. Length of larger embryo about 3.5 mm. FIG. 6. Same embryos as Fig. 5, opposite surface.



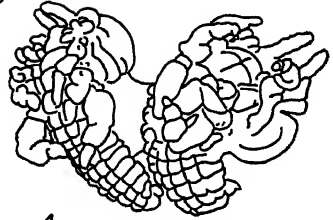
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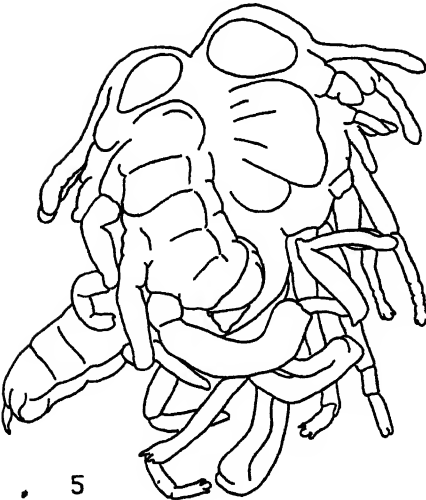
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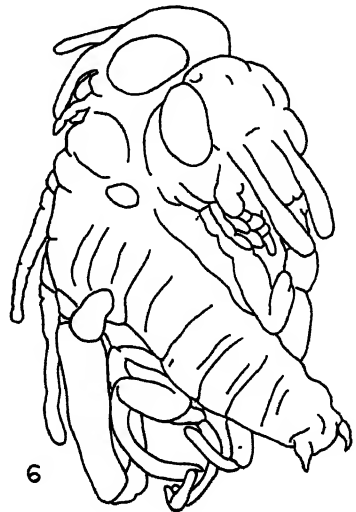
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6

embryo is located on the ventral or concave surface of the egg with its head close to the micropylar end while its abdomen extends anteriorly along the ventral surface of the egg.

The posterior end of one of the eggs which contained extra embryos is shown in fig. 1. Two of the embryos in this egg were well-developed and were separated by a considerable distance while a third embryo, retarded and less normal in appearance, lay close to the caudal end of the larger one of these two. This egg was laid in the laboratory and had been kept at 100% R. H. and 27° C. When fixed (Aug. 8, 1946) it was about three months old.

The other unusual egg, fixed July 18, 1945, was taken from a pod laid in the field about two months previously and contained two embryos (fig. 2) younger than those in the first egg. The larger and better-developed embryo was about 0.2 mm. long. The smaller one was quite abnormal in shape.

### *Melanoplus differentialis*

During the past twenty years hundreds of thousands of eggs of *Melanoplus differentialis* have been examined and dissected by one of us (Slifer). Large numbers of abnormal embryos of many different kinds have been found, particularly in some of the highly inbred stocks, but only two eggs which contained complete or nearly complete twin embryos have been seen. These were both found in living eggs from which the chorion had been removed with sodium hypochlorite (Slifer, 1945).

The first egg, found Oct. 20, 1944, was allowed to continue its development for three weeks longer at 25° C. When first seen the embryos were located at the posterior end of the egg with their heads already directed anteriorly. Both seemed to be nearly complete except for their dorsal regions. One faced the convex and one the concave surface of the egg. Their lateral body walls showed regular, rhythmic contractions as is usual at this stage. During the succeeding three weeks the embryos grew in a surprisingly normal manner. Much, but not all, of the yolk was engulfed, the appendages elongated and the hind femora acquired the brown pigment spots characteristic of embryos which are due to hatch about a week later.

When it became apparent that development had slowed down and was about to stop the embryos, still alive, were dissected out of the egg and fixed (Figs. 5 and 6). They were then found to be united by their anterior dorsal surfaces. One embryo, except for the region where it was joined to its twin, was entirely normal in appearance but the abdomen of the other was shortened and its segments telescoped together. Apparently the second embryo had failed to secure enough yolk to fill its midgut. The tenth abdominal sternum of the larger embryo appeared to be that of a female (Nelsen, 1931) but the sex of the other embryo could not be determined.

The second egg with twin embryos was found Feb. 23, 1945, and was opened in Ringer's solution and the contents fixed at once. The embryos, still attached, are shown in figs. 3 and 4. While still in the egg both embryos were back to back, their lateral walls were in contact and their heads were not far from the posterior end of the egg. When

placed in the fixative their heads and abdomens were flexed dorsally and the lateral body walls on one side broke apart. Both of these embryos were perfect externally, of the same size and at the same stage of development. The well-developed appendages on the tenth abdominal sterna showed them both to be males (Nelsen, 1931).

## SUMMARY

Several eggs which contained two or more embryos have been found in *Dociostaurus maroccanus* and *Melanoplus differentialis*. Polyembryony, in these species, is of the type described by Patterson (1927) as accidental or sporadic.

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PAPÊIS AVULSOS DO DEPARTAMENTO DE ZOOLOGIA, VOL. VII. Secretaria da Agricultura, Indústria e Comércio, São Paulo, Brasil, 1947.

This volume of *Papéis avulsos* is composed of twenty-five articles, most of them on arthropods. Two are of more general interest: *Nota sobre Nomenclatura Zoológica* by AFRÂNIO DO AMARAL and *Notas de Nomenclatura I* by LAURO TRAVASSOS Filho. Others include an article on Tipulidae from São Paulo by CHARLES P. ALEXANDER, several on Diptera by MESSIAS CARRERA, several on Coleoptera by R. L. ARAUJO and E. NAVAJAS and one on Hesperidae—a faunal list—by KENNETH J. HAYWARD. BENEDICTO A. M. and HELIA E. M. SOARES contribute nine articles on spiders and harvestmen. The reviewer notes a considerable number of descriptions of new species.—A. W. L.

## NEW TRICHOPTERA FROM PUERTO RICO

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University of Wyoming

Very few Trichoptera have as yet been recorded from the West Indies; still fewer are known from Puerto Rico. It was with considerable interest that a collection of Trichoptera from Puerto Rico was examined and found to contain a number of species, five of which were new. I have been informed by Dr. H. D. Pratt who collected these specimens that material secured from Lake Tortuguero, which is in Vega Baja township, are from the only large fresh water lake in Puerto Rico and that it is located practically at sea level; specimens from El Yunque are from the best known high mountain in Puerto Rico and were collected at about twenty-two hundred feet elevation; those collected at Luquillo are from "roaring streams coming out of the high tropical rain forest" and were taken at approximately five hundred feet elevation. I would like to express my gratitude to Dr. H. D. Pratt of the U. S. Public Health Service for collecting these specimens.

Unless indicated otherwise types of these new species are in the author's collection at the University of Wyoming.

### *Oecetis pratti* n. sp.

This species can be readily separated from other described species of the genus by the long slender, apically enlarged tenth tergite, the fingerlike claspers when viewed laterally and the peculiar aedeagus.

Male.—Length 9 mm. General characteristics, color and size resembles *Oecetis inconspicua* Wlk. Genitalia as in fig. 1. Ninth segment widest in the middle and with a rather dense brush of setae along ventral margin. Tenth tergite slender, gradually enlarged apically to a rounded knob-like apex when viewed from either lateral or dorsal aspect; a few short scattered setae apically; directed ventrad beyond cerci, dorsal view as in fig. 1A. Cerci flattened, about same width throughout, rounded apically. Claspers viewed laterally, digitate, basal portion somewhat angulate; mesal portion projected mesad as a wide flat flange almost to aedeagus, its distal margin studded with short setae. Aedeagus tubular, robust, distal evaginated portion semi-membranous, turned abruptly dorsad into a triangular apex. When seen from ventral aspect a pair of slender acute heavily sclerotized teeth are discernable at base of the triangular apical portion.

This species is named in honor of Dr. H. D. Pratt who collected not only this species but all the other species recorded herein.

*Holotype*, male.—El Yunque, Puerto Rico, May, 1945, H. D. Pratt.

### *Oecetis inconspicua* (Walker)

Vega Baja, Puerto Rico, March, 1944, H. D. Pratt, 2 males, 7 females.  
Lake Tortuguero, Puerto Rico, May 25, 1944, H. D. Pratt, 1 male.

*Chimarra luquillo* n. sp.

This beautifully colored species is a close relative of *Chimarra braconoides* (Wlk.) originally described from Santo Domingo. It can readily be separated from that species by the tenth tergite, the ventromesal portion of the ninth sternite and several other differences in the male genitalia.

I would like to express my appreciation to Mr. Nathan Banks for comparing this species with determined species in the Museum of Comparative Zoology and stating that it is distinct from other described species.

In both sexes the head, body, antennae and legs bright yellow, setae of the head and thorax yellow, spurs brownish. The fore wings blackish with a number of bright silver markings as shown in fig. 2. In the male the spur of the fore leg minute, the claws greatly modified, the inner quite similar in shape to the outer claw, but only about one-half its size, the outer claw, fig. 2A, almost as long as the last tarsal segment. In the female the claws are minute and unmodified.

Male.—Genitalia as in fig. 2B, and fig. 2C. Eighth tergite curved ventrad distally, lateral portion produced caudad to form an inverted V when seen from caudal aspect, ventro-distal lobes somewhat more heavily sclerotized than remainder and bearing a dense brush of minute blackish setae. Ninth segment with ventral portion wide, ventromesal projection directed caudad when viewed ventrally, fig. 2C, slightly upturned when viewed laterally; dorsally ninth tergite reduced to about one-tenth width of ninth sternite; lateral margin produced into an irregular finger-like process, inner ventral angle acute; ventrad to this the lateral margin is produced into a circular process bearing a few small setae. Claspers rather inconspicuous, somewhat circular when viewed ventrally, bearing a few small setae. Cercus obovate, bearing a few setae, situated on lateral aspect of ninth segment ventrad from base of tenth tergite. Tenth tergite with an attenuated dorsal angulation, lateral and ventral margins nearly straight forming an acute apex; when seen from dorsal aspect apical margin bifid, forming a deep triangular incision. Aedeagus in a sclerotized tubular process, which is incised ventrally to about one-half its length; membranous aedeagus projected caudad from this structure, internally two pairs black spines.

Female.—Very similar in coloration and general appearance to the male, but lacking such modifications as the claws of the forelegs that are present in the males.

*Holotype*, male.—Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt.

*Allotype*, female.—Same data as for Holotype.

*Paratypes*, 109 males, 47 females.—Same data as for Holotype.

Male and female paratypes are deposited in the Entomological collections of the University of Minnesota, the Illinois Natural History Survey and the Museum of Comparative Zoology.

*Chimarra aterrima* Hagen

Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt, 1 male, 1 female.

*Cheumatopsyche protera* n. sp.

This species differs radically from other described species. Of the known species it is probably one of the most generalized in the genus.

Male.—Length 6 mm. Wings brownish with a distinct white spot along margin of forewing where  $R_1$  and  $R_2$  joins margin. Spurs 1-4-4. Diagnostic characters apparently restricted to genitalia.

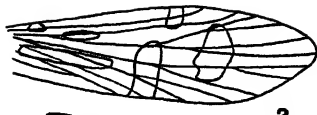
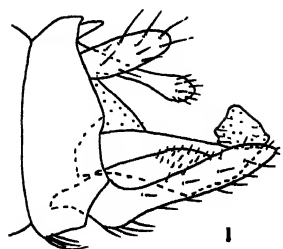
Genitalia as in fig. 3. Tenth tergite long, prominent, when viewed laterally gradually tapering toward distal margin and directed dorsad; lateral processes ovate, not raised dorsad appreciably, bearing a few small setae apically; dorso-lateral surface with a distinct fold with a group of strong setae directed cephalad; baso-mesal portion, viewed dorsally, fig. 3A, with a patch of irregularly placed, dense, flat setae. Claspers with basal segment about twice length of apical, apex considerably narrowed, fig. 3B; apical segment curved laterad but not quite touching one another, enlarged apically, apex acute, bearing several minute setae. Aedeagus with basal portion only slightly enlarged, viewed ventrally apical portion considerably enlarged, distal margin emarginate; apex not distinctly divided into apico-lateral lobes as so common in genus; internally a small heavily sclerotized process.

Female.—Length, coloration and other characters very similar to male; apparently diagnostic characters are available only in the genitalia.

Genitalia as in fig. 3C. As would be expected from the curious male genitalia the female eighth, ninth and tenth segments have likewise undergone a remarkable modification which is radically different from other described species. Mesal margins of eighth sternites separated by about one-half their width; when viewed from lateral aspect, ventro-distal corner attenuated caudo-ventrad. Eighth tergum not perceptibly divided from eighth sternum; meso-distal margin with following modifications: a short distance dorsad of eighth sternum margin projected caudad as a large spine-like process and extended beyond as a ridge to which is attached a large flap-like process which extends caudad to opening of clasper receptacle, distal margin minutely serrate, its ventral plate-like projection with inner surface concave to probably aid in holding the clasper of the male as the apparent clasper groove is just below it on the ninth tergum, its dorsal margin inserted on eighth tergum, near base of insertion arise a dense brush of long flat setae; near mesal margin arises another dense brush of long flat setae. Ninth tergum, viewed dorsally fig. 3D, with distal margin irregular and bearing two rows of spines, mesal portion of dorsal surface with a tri-

## EXPLANATION OF PLATE I

FIG. 1. *Oecetis pratii*, male genitalia, lateral aspect; 1A, tenth tergite, dorsal aspect. FIG. 2. *Chimarra luquillo* fore wing; 2A, male outer claw, fore leg; 2B, male genitalia, lateral aspect; 2C, male genitalia, ventral aspect. FIG. 3. *Cheumatopsyche protera*, male genitalia, lateral aspect; 3A, tenth tergite, dorsal aspect; 3B, claspers; 3C, female genitalia, lateral aspect; 3D, female genitalia, dorsal aspect. FIG. 4. *Polycentropus zaneta*, male genitalia, lateral aspect; 4A, female genitalia, ventral aspect. FIG. 5. *Rhyacophila carula*, male genitalia, lateral aspect; 5A, aedeagus.

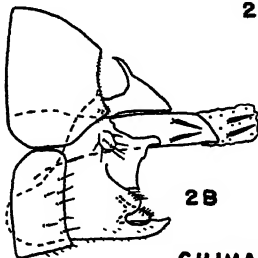


2

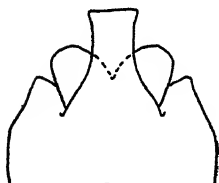
2A



1A

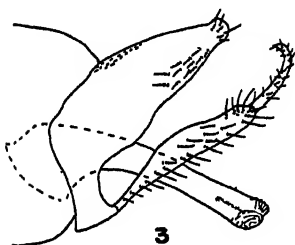


2B



**OECETIS PRATTI**

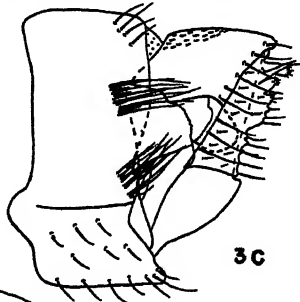
**CHIMARRA LUQUILLO**



3



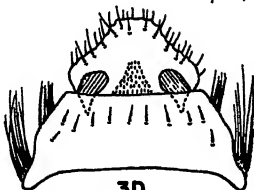
3B



3C

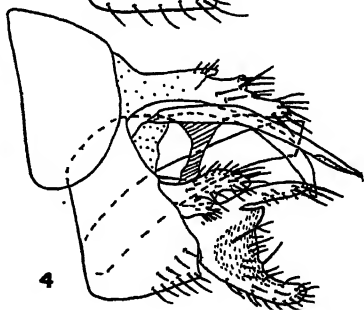


3A

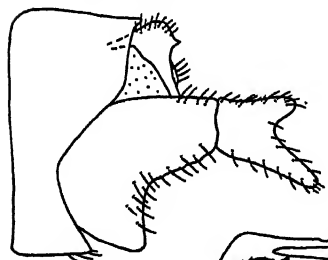


3D

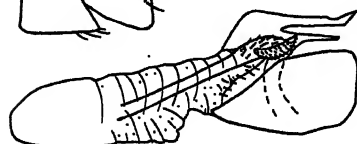
**CHEUMATOPSYCHE PROTERA**



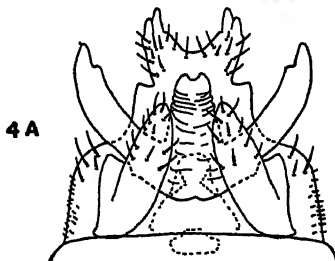
4



5



5A



4A

**RHYACOPHILA CARULA**

**POLYCENTROPUS ZANETA**



angular patch of minute, dense flattened setae; clasper receptacle very large, broadly circular, directed ventro-caudad beyond margin of tenth tergum when viewed laterally, margin slightly irregular and minutely serrate dorsally; internal surface presents a facet appearance; opening to clasper receptacle elongate oval. Plates of tenth tergum with distal margin very irregular, widened ventrally, its margin extending cephalad almost to edge of opening to clasper receptacle.

*Holotype*, male.—Luquillo, Puerto Rico, November, 1943, Light trap, H. D. Pratt.

*Allotype*, female.—Same data as for holotype.

### *Polycentropus zaneta* n. sp.

This species can readily be distinguished from other described members of the genus by the claspers, the cerci, the curious tenth tergite and other details of the male genitalia.

Male.—Male genitalia as in fig. 4. Eighth segment with sclerites unmodified. Ninth sternite with ventral portion wider than dorsal portion, caudal margin irregular. Tenth tergite with basal portion semi-membranous, dorsal margin very irregular and bearing a number of prominent spine-like setae; apical margin emarginate. Each cercus divided near base into two long sclerotized rods, curved gradually caudad and ventrad; outer cercus with apex tapering to a sharp point, a very lightly sclerotized area near apex, directed caudad beyond inner cercus; inner cercus with apex sub-acute; cerci bear no setae. Along meso-lateral margin of ninth sternite arises a prominent process directed caudad, bearing many small and large setae. Claspers large with many large setae, dorsal margin extended caudad as a finger-like process, its dorsal margin convex, its ventral margin minutely serrate, apex bearing several long setae; viewed from ventral aspect apex curved slightly laterad; the ventral lobe directed ventro-caudad, apex blunt, lateral surface concave, process with a number of large and small setae; inner mesal margins gradually divergent from base. Aedeagus tubular, only slightly curved, distal margin extends just beyond tenth tergite.

The head and portions of the appendages are missing from the holotype.

Female.—Genitalia as in fig. 4A. Lateral lobes long, narrow, gradually tapering at apex, widely separated at base; lateral margin produced into a distinct angulation. Dorsad to the lateral lobes is a plate with long, narrow, acute clasper-like projections directed gradually caudad and a lightly sclerotized medial plate emarginate at distal margin. The ano-vaginal opening is lined latero-ventrally with a pair of heavily sclerotized plates and a ventral lightly sclerotized concave plate. The bursa copulatrix circular, supports indistinct.

*Holotype*, male.—Luquillo, Puerto Rico, November, 1943, light trap, H. D. Pratt.

*Allotype*, female.—Same data as for holotype.

*Paratypes*, 1 male, 1 female.—Same data as for holotype.

### *Rhyacophila carula* n. sp.

This species belongs to the *fenestra* Ross, *ledra* Ross section of the genus. It can readily be separated from these and other described

species of the genus by the lateral arms of the aedeagus, the claspers and other details of the male genitalia.

Male.—Length 9 mm. Genitalia as in fig. 5. Sternite of seventh segment with a small acute mesal projection. Tenth tergite narrow, incised apically down the meson its entire length, lateral lobes convex dorsally, distal margin with a small acute heavily sclerotized point. Basal margin of claspers broad, short, ventro-caudal inner surface deeply concave; apical segment short, distal margin incised to form a short blunt dorsal projection and a long gradually tapering ventral projection, inner surface of dorsal projection with abundant short brown setae, apical two-thirds of inner surface of ventral projection with sparsely scattered short brown setae. Aedeagus, fig. 5A, consists of a pair of lateral arms and a pair of thin ventral plates with sides flared dorsad, from ventral aspect these plates are fused along mesal margins and with a deep narrow incision along distal margin; the mesal portion is projected abruptly dorsad as a blade-like ridge divided into a dorsal arm, long, slender and acute apically, and a ventral arm which is shorter and narrower. Lateral arms in a membranous pocket from which they can apparently be extended, basal portion long and narrow, apical portion cup-shaped when viewed laterally, densely covered with short brown setae; from dorsal aspect apex widened, concave and with a striated appearance.

Female.—Length 9 mm. Similar in general appearance to male. Apical segments of abdomen tubular and tapering. Sixth sternite with a prominent, acute conical projection. Eighth sternite deeply incised.

*Holotype*, male.—Luquillo, Puerto Rico, November, 1943, light trap, H. D. Pratt.

*Allotype*, female.—Same data as for holotype.

A REVISION OF THE TRIBE SCAPHYTOPINI (Homoptera, Cicadellidae)  
IN AMERICA NORTH OF MEXICO, by LEON W. HEPNER. The University of Kansas Science Bulletin, Vol. XXXI, part II, No. 16, pages 413-541, plates XXIII-XXIX, Nov. 1, 1947.

The study of more than twenty-five thousand specimens in the revision of a group containing seventy-three species should be an ample guaranty of the practical value of the work. In his opening historical sketch of the taxonomy of the group the author indicates several changes in generic usage, particularly the suppression of most of the genera described by Ball, a step for which his abundant material and careful study should be an adequate foundation.

The treatment is admirable for practical use. Genera and subgenera are described and provided with keys to the included species. Each species is described in detail and notes are included on the location of types, geographic distribution, host plants and comparison with other species. Bibliographic citations are limited to the original descriptions of species and synonyms, with a list of fifty-six titles at the end of the text.

With the exception of plate XXIII, which illustrates structural and genitalic characters in line cuts, the plates are unique. They are made up of half-tone *negative* figures of male and female genitalia. The author's technique of making these figures as photomicrographs directly on paper must be a very convenient method of securing records for study, once the apparatus is set up. Although the reviewer's experience with photomicrographs of genitalia leads him to prefer good drawings, these figures appear so clear in detail that they should be entirely adequate.—A. W. L.

# THE NORTH AMERICAN GALL MIDGES OF THE TRIBES CATOTRICHINI AND CATOCHINI (Diptera: Itonididae (Cecidomyiidae))

A. EARL PRITCHARD,<sup>1</sup>  
University of California,  
Berkeley

The classification of the gall midges of the tribes CATOTRICHINI and CATOCHINI was in a state of confusion prior to the work of Edwards (1938). At that time Edwards proposed these tribal concepts, erected two new genera, and redescribed a few of the species known to occur in the northern hemisphere. Two of the previously described genera were excluded from his revision because he believed that they properly belonged to the SCATOPSIDAE, and most of the types were not available to him for examination.

The present study constitutes a comprehensive review of all the species known to occur in North America. Thirteen species were described by Felt of which six are here considered valid; one species was described by Alexander. Most of these are considered rare, and nothing is known of their biology. Two species are noteworthy because of having been taken off snow in wintertime, and others have been captured only in the late fall or early spring.

The writer is grateful to Dr. R. D. Glasgow and Dr. C. C. Adams for the privilege of studying the types in the New York State Museum, to Mr. Nathan Banks for the privilege of studying the type in the Museum of Comparative Zoology, to Mr. C. F. W. Muesebeck and Dr. E. A. Chapin for the many courtesies extended in studying the types in the U. S. National Museum, and to Professor C. E. Mickel and Dr. S. W. Bromley for additional specimens.

## Tribe Catotrichini Edwards

*Catotrichini* Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938.  
*Catotrichiariae* Mani. Ind. Jour. Ent., 7: 191, 1946.

The CATOTRICHINI apparently comprise the most generalized members of the family ITONIDIDAE. The group resembles the LESTREMIINI and CATOCHINI in wing venation in that  $M_1$  and  $M_2$  are present, but it differs from both in that  $M_{3+4}$  arises from  $M$  rather than being free. This vein ( $Cu_1$  of Edwards) is distinct from  $Cu_1$  which, when present in the ITONIDIDAE always forms a branch of  $Cu$  near its middle. Although either  $M_{3+4}$  or  $Cu_1$  may be found in the LESTREMIINAE, the two veins occur simultaneously in some of the more generalized ITONIDINAE. The flagellum of the CATOTRICHINI bears scattered bristles but no definite whorls, a condition that is otherwise found only in the genus *Anarete* (LESTREMIINI).

<sup>1</sup>Assistant Professor of Entomology and Assistant Entomologist in the Experiment Station.

The tribe contains but a single genus to which two North American and one Japanese species have been referred. The female is unknown.

### Genus *Catotricha* Edwards

*Catotricha* Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938.

Genotype.—*Catocha americana* Felt, by original designation.

#### KEY TO SPECIES, NORTH AMERICAN MALES

1. Medial fork distinctly longer than stem; r-s less than three times length of r-m; ninth tergite very shallowly and broadly emarginate; disticlasper very long and slender with short internal projection proximally.....*americana*  
 Medial fork distinctly shorter than stem; r-s about five times length of r-m; ninth tergite deeply and broadly emarginate; disticlasper short and broad, with slender internal projection.....*subobsoleta*

#### *Catotricha americana* (Felt)

*Catocha americana* Felt. Bull. N. Y. State Mus., 124: 309, 1908 (fig. antennal segment); Bull. N. Y. State Mus., 165: 130, 1913 (fig. adult, antennal segment).

*Catotricha americana* (Felt): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938 (fig. wing).

This species, known from a single male, has been adequately described and illustrated by Felt and Edwards.

Monotype.—Male, at the New York State Museum.

Specimen examined.—NEW HAMPSHIRE: one male, Franconia, A. T. Slosson. (monotype of *americana*).

#### *Catotricha subobsoleta* (Alexander)<sup>1</sup>

*Catocha subobsoleta* Alexander. Insec. Inscit. Mens., 12: 82, 1924.

*Catotricha subobsoleta* (Alexander): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 102, 1938 (fig. wing, antennal segment, male genitalia).

The holotype male of this species has been adequately figured by Edwards. Three additional males were recently sent to the writer by Dr. S. W. Bromley.

Holotype.—Male (on cardpoint), in the U. S. National Museum.

Specimens examined.—OREGON: three males, Boyer, April 11, 1937. WASHINGTON: one male, Longmire Springs, June, 1917, H. G. Dyar (holotype of *subobsoleta*).

### Tribe *Catochini* Edwards

*Catochini* Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 104, 1938.

*Catochariæ* Mani. Ind. Journ. Ent., 7: 191, 1946.

The tribe CATOCHINI differs from the CATOTRICHINI and the LESTREMIINI in that the humeral cross-vein and the plical vein (An of Edwards) are absent. It further differs from the LESTREMIINI in having three, rather than two ocelli and by possessing sclerotized spermathecae in the female. The medial fork is shorter than the stem and the costa usually extends well beyond  $R_4$ .

<sup>1</sup>The drawing of the male of *Hormosomyia oregonensis* Felt which was presented by Cole and Lovett (Proc. Calif. Acad. Sci., 11: 223, 1921) was based upon a misidentification, and the specimen figured actually represents *Catotricha subobsoleta* (Alex.).

Members of the CATOCHINI have been described from Europe, North America and India, but only the genus *Catocha* has been recognized outside North America except for *Catarte* which is known only from Europe.

#### KEY TO GENERA

1. Medial fork very uneven, the upper branch sigmoid;  $R_5$  short, joining costa just beyond middle of wing; costa extending very shortly beyond  $R_5$ ; flagellar segments of both sexes short and broad, each with a pair of budlike sensoria..... *Tritozyga*  
 Medial fork with the branches even;  $R_5$  extending well beyond middle of wing; costa extending well beyond  $R_5$ ..... 2
2. Wings with macrotrichia; empodium as long as claws..... 3  
 Wings without macrotrichia; empodium very short..... 4
3.  $Cu_2$  strongly bent;  $R_5$  not reaching end of wing; flagellar segments of female without stems, each with a pair of bud-like sensoria; dorsal eye widely separated from lateral eyes..... *Neocatocha*  
 $Cu_2$  evenly curved;  $R_5$  reaching end of wing; flagellar segments pedicellate, with forked sensoria; eye bridge 2-3 facets wide..... *Catocha*
4.  $R_5$  strongly arched distally, reaching wing tip..... *Eucatocha*  
 $R_5$  gently curved, not reaching end of wing..... 5
5.  $R_5$  approximate to C, curved anteriorly;  $Cu_2$  evenly curved; antennae of female 8 segmented..... *Catarte*  
 $R_5$  widely separated from C, nearly straight;  $Cu_2$  sigmoid; antenna of female 10 segmented..... *Anocha*

#### Genus *Tritozyga* Loew

*Tritozyga* Loew. Monog. N. Amer. Dipt., 1: 178, 1862 (no species included; fig. wing); Skuse, Proc. Linn. Soc. N. S. Wales, 3: 143, 1889; Kieffer, Bull. Soc. Hist. Nat. Metz, (ser. 2) 8: 53, 1898; Kieffer, Ann. Soc. Ent. France, 69: 447, 1900; Felt, Jour. N. Y. Ent. Soc., 19: 32, 1911; Enderlein, Arch. Naturg., 77 (Bd. 1, Suppl. 3): 192, 1911; Felt, Bull. N. Y. State Mus., 165: 148, 1913; Kieffer, Gen. Insect., 152: 310, 1913; Edwards, Ent. Mon. Mag., 65: 10, 1929; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 1938.

Genotype.—*Tritozyga sackeni* Felt, the first species included, and by subsequent designation of Felt, 1911.

Edwards excluded from consideration the genus *Tritozyga*, stating that he strongly suspected it to belong properly to the SCATOPSIDAE. The wing venation is certainly different from that of any other itonidid, but Loew and Felt were quite correct in placing it in the ITONIDIDAE. *Tritozyga* differs from the scatopsids and agrees with the itonidids in having the eyes bare, the antennae with whorled bristles as well as a few scattered lateral bristles, the proximal end of  $M_{3+4}$  evanescent, the femora slender, and the tibiae not incrassate distally.

The configuration of the radius and costa in *Tritozyga* is rather similar to that of the LESTREMIINI except that the branching of the radius is closer to the base of the wing and the costa extends a little farther beyond  $R_5$ . That the relationships are with the CATOCHINI, however, is shown in the male genitalia which similarly have a terminal brush on the disticlasper, the sclerotized spermathecae of the female, and the absence of the humeral cross-vein and the plical vein. The antennae of *Tritozyga* are very similar in structure to the antennae of *Neocatocha*; and the bend in  $Cu_2$  is rather characteristic of several catochine genera.

The genus *Tritozyga* may be briefly characterized as follows, on a basis of the few specimens of the known species.

Antennae of both sexes similar, with reduced number of segments: 2+8 in male, 2+6 in female; terminal antennal segment long, compound, resulting from fusion of two segments in male and three segments in female, with distal bristles; flagellar segments short and broad, without distal stems; each flagellar segment, including only proximal division of terminal segment, with a proximal whorl of long bristles which are set very wide apart and with a pair of distal, bud-like sensoria. Ocelli three. Lateral eye bridge without facets, the dorsal eye widely separated, 6 to 7 facets wide at middle, Palpi 4 segmented, the first three segments subequal, the fourth a little longer; first segment of female with a small pocket of sensory bristles on proximal portion inside. Wings moderately covered with long, narrow macrotrichia;  $R_5$  only two-thirds as long as wing, the costa extending only a little beyond this and then with a break;  $R_4$  obliterated; fork of M very uneven, the upper branch sigmoid;  $M_{3+4}$  evanescent at proximal end;  $Cu_2$  rather strongly bent, curved and tapering beyond this, evanescent at distal end. Claws slender, acute distally; empodium wide, about as long as claws, densely clothed with short hairs below. Spermathecae two, rather small, round, heavily pigmented including a small neck of the tube. Disticlasper of male genitalia with distal brush.

Felt's figure of the wing, although substantially correct, is somewhat misleading: actually the costa is strong until slightly beyond  $R_5$  where there is a distinct break and  $R_5$  is slightly curved upward at junction with the costa;  $R_5$  is slightly widened at the position of the obsolete  $R_4$ , where it is approximate to  $R_1$ ; r-m below this point is curved downward to M; the upper branch of the median fork is strongly curved at a blunt right angle near origin.

### *Tritozyga sackeni* Felt

*Tritozyga sackeni* Felt. Jour. N. Y. Ent. Soc., 19: 32, 1911; Felt, Bull. N. Y. State Mus., 165: 149, 1913 (fig. wing).

*Tritozyga fenestra* Felt. Insec. Inscit. Mens., 2: 117, 1914. New synonymy.

*Tritozyga borealis* Felt. Jour. N. Y. Ent. Soc., 27: 279, 1919. New synonymy.

*Neocalocha cranbrookii* Felt. Canad. Ent., 58: 266, 1926. New synonymy.

Felt gave no reason for differentiating his proposed species, and the writer has been unable to find any significant differences in the types. Only the type of *cranbrookii* is in fairly good condition, and its wings have been malformed by potassium hydroxide. The male genitalia of the single male are lateral view and cannot be characterized.

Monotype.—Female, in the Museum of Comparative Zoology.

Types of synonyms.—*Fenestra*: monotype female, in the New York State Museum; *borealis*: lectotype female by present designation, in the New York State Museum; *cranbrookii*: monotype female, in the New York State Museum.

Specimens examined.—DISTRICT OF COLUMBIA: one male (monotype of *sackeni*). NEW YORK: one female, Albany, June 3, 1914, D. B. Young (monotype of *fenestra*); one female, one male, Keene Valley, September 15, 1917, H. Notman (lectotype and paralectotype of *borealis*). BRITISH COLUMBIA: one female, Cranbrook, October 14, 1922, C. Garrett (monotype of *cranbrookii*).

Genus *Neocatocha* Felt

*Neocatocha* Felt. Jour. N. Y. Ent. Soc., 20: 236, 1912; Felt, Bull. N. Y. State Mus., 165: 151, 1913; Kieffer, Gen. Insect., 152: 307, 1913; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938.  
*Konisomyia* Felt. Insec. Inscit. Mens., 2: 118, 1914; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 24, 1938. New synonymy.

Genotype.—*Neocatocha marilandica* Felt, monobasic and by original designation.

Genotype of synonyms.—*Konisomyia*: (*Konisomyia fusca* Felt) = *Neocatocha marilandica* Felt, monobasic and by original designation.

Edwards excluded from consideration the genus *Konisomyia*, suspecting that it belonged to the SCATOPSIDAE. This genus, erected on a basis of wing venation, is here shown to be a strict synonym of *Neocatocha*, erected on a basis of antennal structure. The wing venation is similar to that found in other catochine genera except that  $R_s$  is lacking. *Neocatocha* was originally regarded by Edwards (1929) as a synonym of *Catocha*, although he later considered it as possibly distinct. The genus is actually quite distinct, and the following characterization is drawn up from the several known females.

Female antenna with 2+6 segments; terminal segment elongate, rather tapering, compound, composed of three united segments; flagellar segments short and broad, without distal stems, each with a proximal whorl of bristles set wide apart and with a pair of distal, bud-like sensoria. Ocelli three. Lateral eye bridge devoid of facets or with one facet near the middle, the dorsal eye widely separated. Palpi four segmented, the first enlarged, with a deep sensory pore on inside face distally. Wings clothed with slender macrotrichia; C extending to a wide break just above  $M_1$ ;  $R_s$  obsolete; medial fork even:  $M_{3+4}$  evanescent at proximal end;  $Cu_2$  strongly bent, and curved beyond this. Claws slender, acute distally; empodium wide, as long as claws. Spermathecae two, rather small, round, heavily pigmented, including a small neck of the tube.

Felt's sketch of the wing of *marilandica*, as published by Edwards, is very inaccurate and misleading: actually,  $R_s$  is obsolete, its position being indicated only by a slight widening of  $R_5$ ; r-m cross-vein is two or three times as long as  $R_s$ , continuous with  $R_5$ , but curving downward;  $CuP$  is distinct and free;  $Cu_2$  is tapering beyond bend, evanescent at distal end. Felt's drawing of the empodium is too short, and that of the palp omits the characteristic sensory pore.

*Neocatocha marilandica* Felt

*Neocatocha marilandica* Felt. Jour. N. Y. Ent. Soc., 20: 236, 1912; Felt, Bull. N. Y. State Mus., 165: 151, 1913 (fig. antenna, palp, claws); Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938 (fig. wing).  
*Konisomyia fusca* Felt. Insec. Inscit. Mens., 2: 118, 1914. New synonymy.  
*Konisomyia borealis* Felt. Jour. N. Y. Ent. Soc., 27: 279, 1919. New synonymy.

The writer has been unable to make any distinctions in the three type females representing Felt's three species. Felt gave no reason why he considered the second species of *Konisomyia* distinct.

Monotype.—Female, in the New York State Museum.

Types of synonyms.—*Fusca*: monotype female, in the New York State Museum; *borealis*: monotype female, in the New York State Museum.

Specimens examined.—MARYLAND: one female, Plummer's Island, March 24, 1907, W. L. McAtee (monotype of *marilandica*); one female, Plummer's Island, April 12, 1914, W. L. McAtee (determined by Felt as *marilandica*). NEW YORK: one female, Albany, June 2, 1914, D. B. Young, on window (monotype of *fusca*); one female, Albany, June 6, 1914, D. B. Young on window (determined by Felt as *fusca*); one female, Keene Valley, September 15, 1917, H. Notman (monotype of *borealis*).

### Genus *Catocha* Haliday

*Catocha* Haliday. Ent. Mag., 1: 156, 1833; Macquart, His. Nat. Insect. Dipt., 2 (suppl.): 654, 1835; Westwood, Introd. Classif. Insects, Gen. Syn. p. 127, 1840; Walker, Insect. Brit., Dipt., 3: 59, 1856; Schiner, Fauna Austr., Flieg., 2: 412, 1864; Winnertz, Verh. Zool.-Bot. Ges. Wien, 20: 27, 1870; van der Wulp, Dipt. Neerl., p. 78, 1877; Skuse, Proc. Linn. Soc. N. S. Wales, 3: 143, 1889; Kieffer, Bull. Soc. Hist. Nat. Metz, (ser. 2) 8: 52, 1898; Kieffer, Ann. Soc. Ent. France, 69: 438, 1900; Felt, Bull. N. Y. State Mus., 124: 308, 1908; Felt, Jour. N. Y. Ent. Soc., 19: 31, 1911; Enderlein, Arch. Naturg., 77 (Bd. 1, Suppl. 3): 192, 1911; Felt, Bull. N. Y. State Mus., 165: 129, 1913; Kieffer, Gen. Insect., 152: 306, 1913; Edwards, Ent. Mon. Mag., 65: 10, 1929; Mani, Rec. Ind. Mus., 36: 378, 1935; Edwards, Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 104, 1938.

*Mimosciara* Rondani. Sopra Alc. Gen. Inset, Ditt. Mem. Soc. Serv. Ditt. Ital., 1840—reviewed in Isis von Oken, 1844: 451; Rondani, Nuov. Ann. Sci. Nat. Bologna, (ser. 2) 6: 372, 1846; Bigot, Ann. Soc. Ent. France (ser. 3) 2: 475, 1854; Kieffer, Bull. Soc. Ent. France, 69: 442, 1900; Coquillett, Proc. U. S. Nat. Mus., 37: 570, 1910; Edwards, Ent. Mo. Mag., 65: 10, 1929.

*Furcinerva* Rondani. Nuov. Ann. Sci. Nat. Bologna, (ser. 2) 6: 369, 1846 (based on the union of *Zigoneura*, *Lestremia*, *Mimosciara*, and *Catocha*); Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 461, 1854; Kieffer, Bull. Soc. Ent. France, 69: 443, 1900; Coquillett, Proc. U. S. Nat. Mus., 37: 545, 1910.

*Macrostyla* Winnertz. Ent. Ztschr. Ent. Ver. Stettin, 7: 20, 1846; Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 461, 1854.

*Molobraea* Loew.\* Dipt. Beitr., 4: 12, 20, 1850 (a manuscript name of Rondani's based on the union of *Catocha*, *Lestremia*, *Mimosciara*, and *Anarete*); Bigot, Ann. Soc. Ent. France, (ser. 3) 2: 462, 1854 (as *Molobrea*).

*Molobraea* (*Molobraea*) Loew. Dipt. Beitr., 4: 22, 1850 (based on the union of *Lestremia* and *Mimosciara*).

*Molobraea* (*Catocha*) Loew. Dipt. Beitr., 4: 22, 1850.

*Yposatoea* Rondani. Dipt. Ital. Prod., 1: 198, 1856 (based on the union of *Lestremia*, *Zigoneura*, and *Mimosciara*); Coquillett, Proc. U. S. Nat. Mus., 37: 621, 1910.

Genotype.—*Catocha latipes* Haliday, monobasic.

Genotype of synonyms.—*Mimosciara*: *Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910; *Furcinerva*: *Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910; *Macrostyla*: *Macrostyla latipes* Winnertz, monobasic; *Molobraea*: *Mimosciara molobrina* Rondani, by present designation; *Yposatoea*: *Mimosciara molobrina* Rondani, by subsequent designation of Coquillett, 1910.

Rondani's figure (1946, p. 372) of the wing of *Mimosciara lestremia* Rondani shows that this species belongs to the genus *Catocha*. No

\*According to Neave's "Nomenclator Zoologicus," *Molobraea* was described in Loew's "Ueber den Berstein und die Berstein fauna (Dipteren)" p. 32, published in Berlin, 1850. The writer has not seen this paper.



differences between the venation of *M. lestremia* and the genotype, *M. molobrina*, were noted by Rondani, and it would appear that they are congeneric. Edwards suggested that *Mimosciara* is probably a synonym of *Catocha* (and that *molobrina* is probably a synonym of *latipes* Haliday), not *Lestremia* as commonly listed, and it seems that this course should be followed.

Edwards has shown that *Catocha* contains a single species or species complex in northern Europe. A single, closely related species is known from the United States.

### *Catocha slossonae* Felt

*Catocha slossonae* Felt. Bull. N. Y. State Mus., 124: 309, 1908; Felt, Bull. N. Y. State Mus., 165: 132, 1913 (fig. antennal segment, distal segments of palp).  
*Neocatocha sylvana* Felt. J. N. Y. Ent. Soc., 27: 280, 1919. New synonymy.

*Catocha slossonae* is very similar to *C. latipes* Haliday and may prove to be a synonym of that species. The venation is as in the typical form figured by Edwards, 1938 (fig. a), except that the margin between the branches of the medial fork is only one-half as long as  $M_2$ . The male genitalia are similar to the typical form (fig. k), although the black patch of the disticlasper appears longer and narrower. The bristles of the antennal whorl are more numerous (fig. e).

The female described by Felt as *Neocatocha sylvana* is very similar to *latipes* Haliday, and there is no good reason for considering it separate from *slossonae*. The wings are brownish (not hyaline).

Monotype.—Male, in the U. S. National Museum.

Types of synonyms.—*Sylvana*: monotype female, in the New York State Museum.

Specimens examined.—NEW HAMPSHIRE: one male, Franconia, A. T. Slosson (monotype of *slossonae*). NEW YORK: one female, Keene Valley, August 14, 1917, N. Hotman (monotype of *sylvana*).

### Genus *Eucatocha* Edwards

*Eucatocha* Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938.

Genotype.—*Catocha barberi* Felt, monobasic and by original designation.

The genus *Eucatocha* is represented by a single species the female of which is unknown.

### *Eucatocha barberi* (Felt)

*Catocha barberi* Felt. Bull. N. Y. State Mus., 165: 131, 1913.

*Eucatocha barberi* (Felt): Edwards. Proc. Roy. Ent. Soc. Lond., 7 (ser. B): 106, 1938 (fig. wing, male genitalia, antennal segment).

This species has been adequately redescribed by Edwards after examining the paralectotype male. The lectotype, selected by C. T. Greene, clearly shows three ocelli; the hypopygium is lateral view.

Lectotype.—Male, by present designation, in the U. S. National Museum.

Specimens examined.—WISCONSIN: two males, Crab Lake, Vilas Co., December, 1907, H. S. Barber, —30° F. (lectotype and paralectotype of *barberi*).

Genus *Anocha* n. gen.

Genotype.—*Neocatocha spinosa* Felt.

*Anocha* is closely related to *Catarete* Edwards (1929) from which it differs in having  $R_5$  nearly straight, widely separated from the costa,  $Cu_2$  strongly bent,  $M_{3+4}$  evanescent at proximal end, and the female antenna with eight flagellar segments, being unreduced in number. The wing venation is similar to that of *Neocatocha* from which it differs in lacking alar macrotrichia and the female flagellar segments unreduced in number, each pedicellate and with only short bristles distally. *Anocha* may be briefly characterized as follows on the basis of the several known females and one damaged male.

Antenna of female with 2+8 segments; flagellar segments short pedicellate (see figure), each densely set with sensory bristles distally on enlargement; terminal segment simple, with slender bristles distally. Antenna of male with 2+14 segments; flagellar segments with long

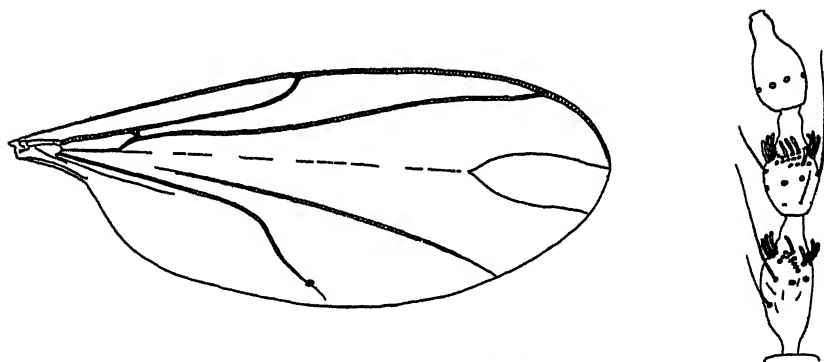


FIGURE 1. Wing and proximal flagellar segments of *Anocha spinosa* (Felt), female, Plummer, Minnesota.

distal stems and sensory bristles distally on the enlargements. Ocelli three. Lateral eye bridge three facets wide. Palpal segments four, the first with a large pocket of sensory bristles on inner side. Wings (see figure) devoid of macrotrichia; C extending to break just above  $M_1$ ;  $R_1$  long;  $R_5$  long, slightly sigmoid, widely separated from C;  $R_2$  very short, transverse, nearly obliterated; r-m much longer than  $R_5$ , continuous with  $R_5$  and curved downward to meet M;  $M_{1+2}$  weak, much longer than the short fork;  $M_{3+4}$  evanescent proximally;  $Cu_2$  sharply bent and then curved, extending practically to margin, claws slightly curved, tapering; empodium very short. Spermathecae two, moderate-sized, round, heavily pigmented including narrow neck of tube.

*Anocha spinosa* (Felt), new combination

*Neocatocha spinosa* Felt. Bull. N. Y. State Mus., 165: 152, 1913.

*Neocatocha nylanderii* Felt. Occ. Papers. Boston Soc. Nat. Hist., 5: 207, 1926.

New synonymy.

The monotype females of both of Felt's species agree well with a female collected in Minnesota. The adults appear in winter when they may be collected off snow.

Type.—Monotype female, in the U. S. National Museum.

Types of synonyms.—*Nylanderi*: monotype female, in the New York State Museum.

Specimens examined.—MAINE: one female, Woodland, December 1, 1917, Olof O. Nylander, probably off snow (monotype of *nylanderi*). MINNESOTA: one male (abdomen missing), one female, Plummer, November 17, 1933, D. G. Denning, off snow following —12° F. UNKNOWN LOCALITY: One female, December 16, 1873, A. R. Barber (monotype of *spinosa*)—this specimen could possibly be from A. W. Barber who was in Wisconsin at that time.

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**BASIC BOTANY**, by FRED W. EMERSON. xi+372 pages, numerous figures. The Blakiston Company, Philadelphia and Toronto, 1947. Price \$4.00.

Elementary textbooks can be very useful even to professional scientists, but they rarely inspire one. Dr. Emerson's *Basic Botany* is an exception. In the first place it is a beautiful book, the binding being a colorful reproduction of a mountain scene from some arid region of the west. The reviewer suspects that the lovely blue sky and white clouds will soil readily in the hands of college students and that the result will be more conspicuous than the average dog-eared text, but the covers should have served a useful purpose by that time.

The typography and format are very clear. Although the reviewer does not like a two-column page he recognizes that this is a matter of opinion. Chapter headings are large enough to be conspicuous. They are followed by a brief general statement on the contents of the chapters and by a list of principal topics which reappear in the text as boldface paragraph heads. Line drawings are clearly executed and very well reproduced, while half-tone illustrations vary more widely in quality. A frontispiece is made up of eight colored illustrations of plants of the major groups. A novel feature of the book is the absence of figure numbers, the figures merely being placed near the part of the text which refers to them.

The contents of the book follow a familiar pattern, proceeding from biological fundamentals to metabolism, structure of plants, and special functions. Genetics and evolution are followed by a taxonomic survey of the plant kingdom and this by two ecological chapters. The book concludes with an ample index.

The author's treatment of these materials should make the book an unusually useful one. He displays a happy faculty for selecting enough facts to establish his points without making the treatment difficult or pedantic, and his facility in the use of English has produced a very readable text. Even though the reviewer's knowledge of botany is entirely adequate for his needs, he has actually enjoyed reading page after page and looks forward to having the book available for reference. Even the amazing inertia of many students who register for introductory science courses should give way before this treatment, which is little short of entertaining.

We wish the author and the publishers the success which their excellent collaboration deserves.—A. W. L.

## NOTES ON THE SELYSIAN TYPES OF *EPIGOMPHUS* *PALUDOSUS* HAGEN IN SELYS

LT. COL. F. C. FRASER, I.M.S. Retd., F. R. E. S.

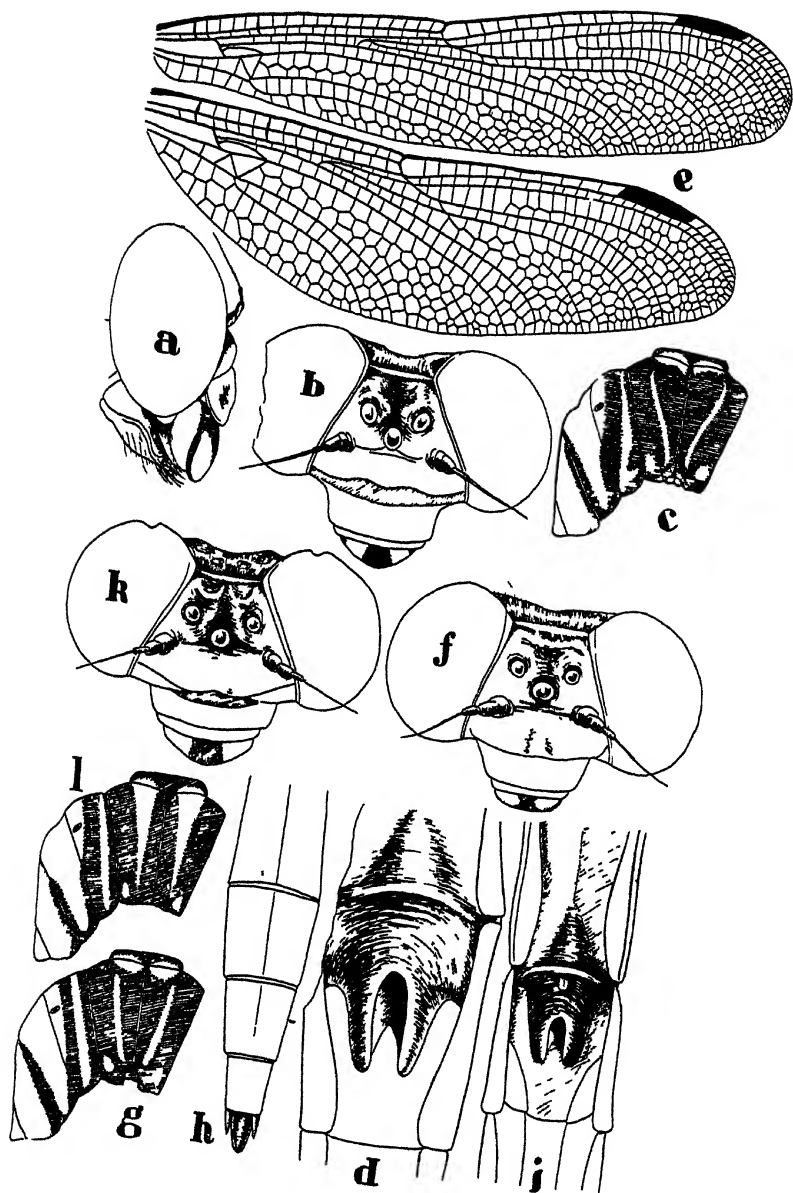
I am indebted to the authorities in charge of the Brussels Museum and in particular to Dr. Antoine Ball for their courtesy and kind co-operation whereby I have been able to make a re-examination of the supposed types of *Epigomphus paludosus* Hagen in Selys. The species was first described in the Syn. Gomphines, and the type, which was said to be in Dr. Hagen's collection, was given as from Brazil. Kirby, in his Cat. Odonata, 1890, p. 71, ascribed the species to Selys but the Mon. Gomphines was written in collaboration with Dr. Hagen, and the Synopsis was a résumé of this work by the two authors, as is stated in the preface to the latter work: thus the correct course to adopt in the present case is to give the authorship to Hagen in Selys. It is not certain whether the Hagenian types went eventually into the Selysian collection or were deposited in the Königsberg Museum but I believe into the former prior to Hagen emigrating to the United States.

There are six specimens labelled as *Epigomphus paludosus* in the Selysian collection and I find two pairs of the same species in the McLachlan collection now in the British Museum (Natural History) which I have also been able to examine. An examination of the Selysian specimens has resulted in the discovery that only three of them are *paludosus*, two being determined by myself as *obtusus* Selys, and the sixth specimen as *quadracies* Calvert. All except one of the specimens, a male of *paludosus*, are females and the difficulty was met with as to which of the two females of *paludosus* was the actual type. It is unfortunate that types were not designated by the old authors, so that this difficulty is constantly cropping up. In the present case, a number of facts point to one particular female as being the type. This specimen bears all the marks of old age, the wings have been glued on and the base of the abdomen has undergone much repair. It bears 3 labels: 1. Green, "Tijuca," "P. B." 2. "Collection of Selys. *Epigomphus paludosus* Hag." and 3. "*Epigomphus paludosus* H., ♀," this latter in Selys' own handwriting. "P. B." in all probability refers to P. Beselke, the collector of the type mentioned in the Mon. Gomph. It is the only specimen from Tijuca, a locality which I have not been able to find in my maps of Brazil. The male and other female and the two pairs of *paludosus* in the McLachlan collection are all labelled from Minas

### EXPLANATION OF FIGURE 1

*Epigomphus obtusus* Selys, female. a. Lateral view of head. b. Dorsal view of head. c. Markings of thorax, diagrammatic. d. Genitalia. e. Wings of female.  
*Epigomphus paludosus* Hagen in Selys. f. Dorsal view of head. g. Markings of thorax, diagrammatic. h. End of abdomen of female. i. Genitalia of female.  
*Epigomphus quadracies* Calvert. k. Dorsal view of head. l. Markings of thorax, diagrammatic.

FIGURE 1



Geraes, Brazil, and we know that these particular specimens were collected at a much later date as mentioned by Selys in his 3rd Add. Syn. Gomph., 1873. Thus by a process of exclusion, we are reduced to the single female from Tijuca and I think there can be no doubt about it being the actual type. I have made the following notes and figures of the six Selysian specimens in the hope that they may be of some assistance to those studying this interesting genus.

Specimen 1. Type female. Determined as *paludosus* by Selys himself.

It agrees closely with the detailed description in the Mon. Gomph both as to measurements and markings although the colouring has faded and the markings of the abdomen are difficult to make out. All the legs are still intact although somewhat glued up: the hind femora bear 6-8 spines longer and more robust than the rest: nodal

index of wings  $\frac{12-16}{12-13} | \frac{17-13}{12-11}$  : an incomplete basal antenodal in all

wings. The antehumeral stripes (fig. 1. g.) are narrow, nearly straight, converging strongly above and well separated from the mesothoracic collar below. There is a well-defined upper triangular spot, the only vestige of a humeral stripe on each side. The vulvar scale (fig. 1. i.) is roughly half the length of segment 8, is shaped like a split-rivet, deeply incised and rather obtuse at apex. The curious cone-like structure between the anal appendages at the end of the abdomen, which Calvert terms the 11th abdominal segment, is certainly the *appendix dorsalis*, and is highly characteristic for the genus.

Specimen 2. A male bearing 6 labels: 1. Pink, "126," 2. White with black border at one end and bearing "MLan" (? McLachlan), 3. Green, a blank. 4. White, "Minas Geraes," 5. White, "Collection Selys, *Epigomphus paludosus* Hgn" (in an unknown handwriting), and lastly 6. White, "*Epigomphus paludosus* H, ♂" (in Selys' own handwriting).

This specimen is in poor condition, the apex of the left forewing missing and the abdomen in pieces but glued on to a strip of wire, segments 3 and 6 being absent, and the 10th with the dorsum broken and the apices of the right anal appendages missing. All legs are present, the hind femora with the flexor and outer sides coated with very small spines which become arranged into outer and inner rows distally, the outer row being the more robust and most widely-set. The tibiae with a few short stout spines numbering 8 or 9 in

the hind pair. Wings with nodal index:  $\frac{? - 14}{11 - 10} | \frac{15 - 11}{12 - 10}$  ; a basal

incomplete antenodal in all wings; anal triangle and anal-loop both absent; 2 Cuqs in all wings save the left forewing. Markings of thorax similar to the type female but the antehumeral stripes are slightly less divergent and entirely straight. I have labelled this specimen as the *allotype* of *paludosus* and the intact appendages of the left side have served to furnish the figures *a* and *b*, fig. 2.

Specimen 3. A female with 2 labels: 1. Green, "Minas Geraes," and 2. White, "Collection Selys, *Epigomphus paludosus* Hg." -in an

unknown handwriting). This specimen evidently belongs to the same series in the McLachlan collection, which also came from Minas Geraes, and is entirely similar to the females in that series. It is rather smaller than the type female, Abd. 37 mm., Hw. 33 mm.

Nodal index:  $\frac{10-16}{10-12} \mid \frac{15-10}{13-8}$ ; hind femora with inner and outer rows of spines, 7-8 robust ones on the inner side and 5-6 larger ones which merge into smaller spines near base of femora. The end of the abdomen is damaged and the genitalia is missing, otherwise I can find no differences between the specimen and the type save that of size. I think this to be therefore a female of *paludosus*

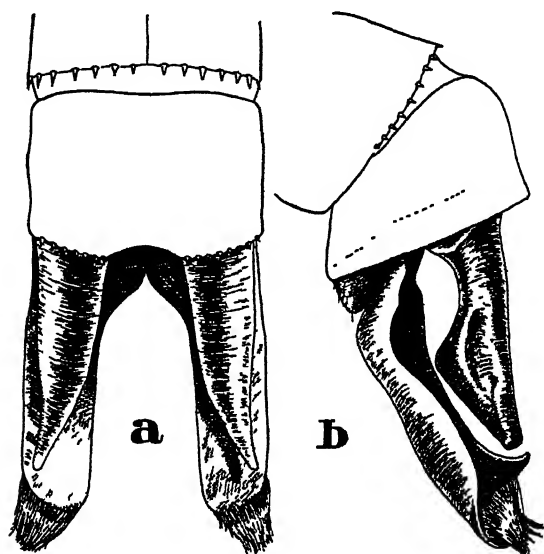


FIG. 2. *Epigomphus paludosus* Hagen in Selys. a. Dorsal view of segment 10 and anal appendages of male. b. The same seen from the left side.

Specimen 4. A female bearing 2 labels: 1. Green, "Chiriquii," 2. "Collection Selys, *Epigomphus paludosus* Hgn." (not in Selys' handwriting). The antehumeral stripes are broadly confluent with the mesothoracic collar, parallel with the middorsal carina and taper to a point ending just below the alar sinus; humeral stripes represented by upper small triangular spots as in *paludosus*. Face and frons a dull olivaceous, labrum with middle third blackish brown, outer thirds citron yellow, anterior border finely black. The posterior surface of the eyes and the upper surface of occiput are deeply pitted with scars due to pressure of the male anal appendages (fig. 1, k.). Nodal index:  $\frac{14-19}{11-13} \mid \frac{20-13}{15-12}$ ; 3 Cuqs in forewings, 2 in the hind; a basal incomplete antenodal in all wings. Abdomen with



only the 3 basal segments present; genitalia missing. Femora yellow within, blackish brown outwardly. The specimen agrees most closely with Calvert's *quadracies*, for which I have determined it.

Specimens 5 and 6. Two females with identical labels. 1. Green, "S. Paulo." 2. White, "*Epigomphus paludosus* Hgn." (not in Selys' handwriting.) Abd. 45 mm., Hw. 36 mm. Nodal index:  $\frac{13-18}{12-14} | \frac{20-13}{13-12}$ ,

$\frac{12-18}{11-14} | \frac{17-12}{12-12}$ ;

3 Cuqs in forewings, 2 in the hind; pterostigma covering 7 cells, longer than in *paludosus*. Antehumeral stripes sinuous, more so in one specimen than in the other, widely divergent below and well separated from the mesothoracic collar. Vulvar scale rather more than half the length of segment 8. These two specimens approach *obtusius* most closely (fig. 1, *a* to *e*).

Two pairs in the McLachlan collection are all labelled *Epigomphus paludosus* Hgn, and all are from Minas Geraes. They do not differ in any noticeable respects from the male and female from the same locality in the Selysian collection mentioned above. The males are in poor condition but it is possible to see that the anal appendages are identical to the male in the Selysian collection. There are thus 3 males and 4 females of *paludosus* known, type and allotype in the Selysian collection, Brussels Museum, cotypes in the McLachlan collection, British Museum.

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#### THE DATES AND EDITIONS OF CURTIS' BRITISH ENTOMOLOGY, by RICHARD E. BLACKWELDER. 27 pages, 4 plates, 1947. Smithsonian Miscellaneous Collections, Vol. 107, No. 5.

The early date and the extent of Curtis' work, together with his citations of genotypes, make the *British Entomology* one of the historically important entomological contributions. Its publication, however, was rather more irregular than that of most early works, hence the careful consideration of dates and type citations presented in this article is essential to its proper evaluation. The author discusses very carefully the inconsistencies of the original publication and reprints of various parts. While he is not able to clear up all uncertain points, his access to various examples of the work has enabled him to furnish a full analysis of the problems involved. In addition to his text he includes facsimile reproductions of several pages and four plates and a bibliography of forty-one items.—A. W. L.

# EMBRYOLOGY OF LUCILIA SERICATA MEIGEN

(Diptera: Calliphoridae)

## PART II. THE BLASTODERM, YOLK CELLS AND GERM CELLS

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The writer (1947) has described the embryology of *Lucilia sericata* from the time of fertilization to the fusion of the cleavage cells with the periplasm, and the consequent formation of the yolk cells. It is the purpose of this paper to present the stages in the development of the blastoderm (primary epithelium) and to describe the formation and fate of certain associated structures: the yolk cells, the germ cells, and the inner periplasm.

### THE BLASTODERM

As already shown (Fish, 1947) the cleavage cells first fuse with the periplasm in the anterior pole at about the level of the original egg nucleus. This protoplasmic merger proceeds dorsally, ventrally and laterally at the same time. From this initial area the cleavage cells fuse with the periplasm anteriorly and posteriorly, reaching the posterior pole last. The nuclei of the cleavage cells are in a peripheral position in the cells at the time of fusion. Although all of the cleavage cells migrate towards the surface, not all of them attain the periplasm but some of them return into the yolk and are recognized as the yolk cells.

The egg now has the appearance (Pl. II, fig. 17) of an outer nucleated continuous layer of protoplasm enclosing the yolk in which are located large amoeboid nucleated masses of cytoplasm (yolk cells), all joined to one another and to the outside layer by fine protoplasmic strands. The whole egg can thus be considered a syncytium. In section, on the peripheral edge, the outer nucleated layer, the blastema, appears as a slightly wavy line while the medial border is indented with yolk and is very irregular. (Pl. I, fig. 1.) The nuclei are circular and lie midway between the peripheral and medial border of the blastema.

Since the area of cleavage cell fusion initially occurs at the anterior pole, it might be expected that this pole would now show a more advanced state of development than the posterior pole. However, if there is a difference in comparative rates of development this difference was not detected. The first mitoses of the blastemal nuclei apparently occur simultaneously throughout the entire layer. Shallow clefts appear on the outer blastemal border and accomplish an incomplete separation of this zone into cell territories or compartments. (Pl. I, figs. 2, 3.) These clefts soon widen and deepen until they penetrate approximately a third of the thickness of the blastemal layer. (Pl. I, fig. 3.) Each cell territory, now rendered more obvious, consists of an outer section of protoplasm and a portion (about one-half) of the nucleus. The remaining portion of the nucleus and scattered yolk

elements are contained in the undivided portion of the blastema. At this stage of development the nuclei lie near the peripheral border. Grossly, the cell territories look alike but when examined in detail there is little uniformity of size and shape.

When the next nuclear division occurs these clefts are all but eliminated and the outer blastemal border again assumes a wavy appearance. (Pl. I, fig. 4.) Generally the lengths of the waves vary but their frequency of occurrence corresponds to the number of nuclei present. The latter are now oval and appear as darkly stained masses. New clefts appear and cell territories are again formed in a fashion similar to the first formed compartments. (Pl. I, fig. 5.) These new territories resemble the first ones except that they are smaller and because of their sharply angled outer edges they are more pronounced. The width of a cell territory at its base does not greatly exceed the diameter of its nucleus. Towards the peripheral edge each compartment tapers slightly and appears somewhat like a truncated cone joined at its base to the undivided area of the blastema. If an imaginary line were drawn connecting the bases of a series of cell territories, it would be almost a straight line. The rate of penetration of the clefts into the

#### EXPLANATION OF PLATE I

All figures are drawn with the aid of the Camera Lucida under the same magnification, 950X. The details are filled in under 1450X.

FIG. 1. Age, about 105 minutes. A longitudinal section through a small portion of the blastemal layer showing the disposition of two nuclei. N—nucleus; Y—yolk.

FIG. 2. Age, about 120 minutes. A similar section of a more advanced stage showing three nuclei. Observe the clefts on the peripheral margin. These clefts may occur obliquely or at right angles. C—cleft.

FIG. 3. Age, about 135 minutes. A more advanced stage showing definite marginal cell territories or compartments. The nuclei appear vacuolate. CT—cell territory.

FIG. 4. Age, about 135 minutes. A stage immediately after nuclear division showing the absence of the original clefts. The nuclei appear smaller and are more compact.

FIG. 5. Age, about 150 minutes. New clefts appear and marginal compartments are again formed. C—cleft.

FIG. 6. Age, about 165 minutes. The clefts penetrate deeply into the blastema. The protoplasm peripheral to the nuclei begins to darken. APD—area of protoplasmic darkening.

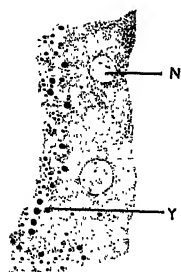
FIG. 7. Age, about 165 minutes. The darkening of the protoplasm continues. Notice particularly the addition of anucleated protoplasmic masses to the blastema. These masses fuse to form the inner periplasm. IP—inner periplasm.

FIG. 8. Age, about 180 minutes. The cell territories are now more pronounced. The nuclei are located more deeply in the blastema. The medial border of the inner periplasm begins to smooth out. IP—inner periplasm.

FIG. 9. Age, about 195 minutes. The peripheral protoplasm is now extremely darkened and appears in section as a dark band. The nuclei are spindle shaped and the fusion of the original blastema and the inner periplasm is complete.

FIG. 10. Age, about 210 minutes. The cell walls penetrate to the yolk. Notice the absorption of yolk by the blastodermal cells. As yet there are no cell walls on the bases of the cells.

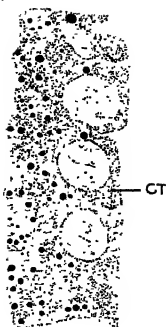
FIG. 11. Age, about 210 minutes. The cell walls penetrate to the yolk. Notice the absorption of yolk by the blastodermal cells. As yet there are no walls on the bases of the cells. CW—cell wall.



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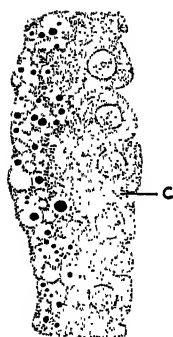
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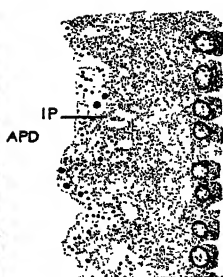
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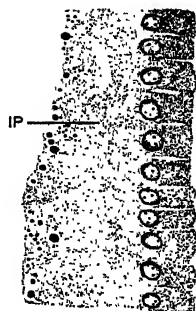
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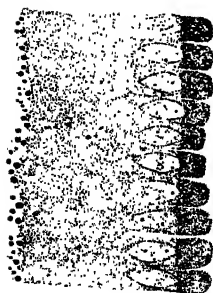
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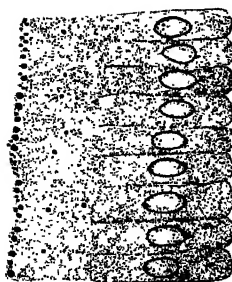
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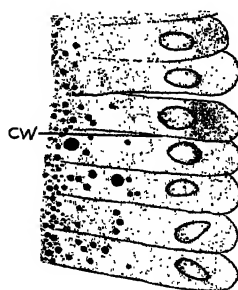
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blastema occurs relatively uniformly, perhaps more rapidly on the dorsal surface. The nuclei are now located more deeply in the blastemal layer and are arranged in an even row.

About the time of the third nuclear division a zone of enucleated protoplasm appears, the inner periplasm. (Pl. I, fig. 7.) It lies beneath the blastemal layer and as development proceeds it fuses gradually with the blastema. After this fusion is completed the "new" blastemal layer is about twice its original thickness. A more thorough description of the inner periplasm will be given in the discussion concerning yolk cells.

Simultaneously with the above development, the protoplasm of the cell territories peripheral to and surrounding the outer half of the nuclei becomes very darkly stained. (Pl. I, figs. 7, 8.) In a later stage the protoplasm is stained so intensely that the outline of the peripheral half of the nuclear membrane is difficult to detect. (Pl. I, fig. 9.)

It may be worthwhile to mention at this time an observation which may be directly correlated with some of the phenomena already described. At the time of fusion of the inner periplasm with the

#### EXPLANATION OF PLATE II

Figures 12-16 are drawn with the aid of the Camera Lucida under 950X and detailed under 1450X. Figures 17-22 are composite drawings of longitudinal sections through the middle of the egg.

FIG. 12. Age, about 120 minutes. A tangential section of the blastemal layer representing a cross-section of Pl. I, fig. 2. N—nucleus.

FIG. 13. Age, about 135 minutes. Represents a cross-section of Pl. I, fig. 4, at the level of the nuclei.

FIG. 14. Age, about 165 minutes. Represents an oblique section of Pl. I, fig. 6, showing compartment arrangement peripheral to the nuclei.

FIG. 15. Age, about 180 minutes. Cross-section of Pl. I, fig. 8, showing peripheral compartment arrangement. N—nucleus.

FIG. 16. Age, about 195 minutes. Cross-section of Pl. I, fig. 11, showing definite cell walls and the honeycomb arrangement of the cells.

FIG. 17. Age, about 120 minutes. A longitudinal section of the entire egg showing the blastema, yolk cells and germ cells in their early development. A—anterior; BL—blastema; D—dorsal; GC—germ cell; N—nucleus; P—posterior; R—reticulum; V—ventral; YC—yolk cell.

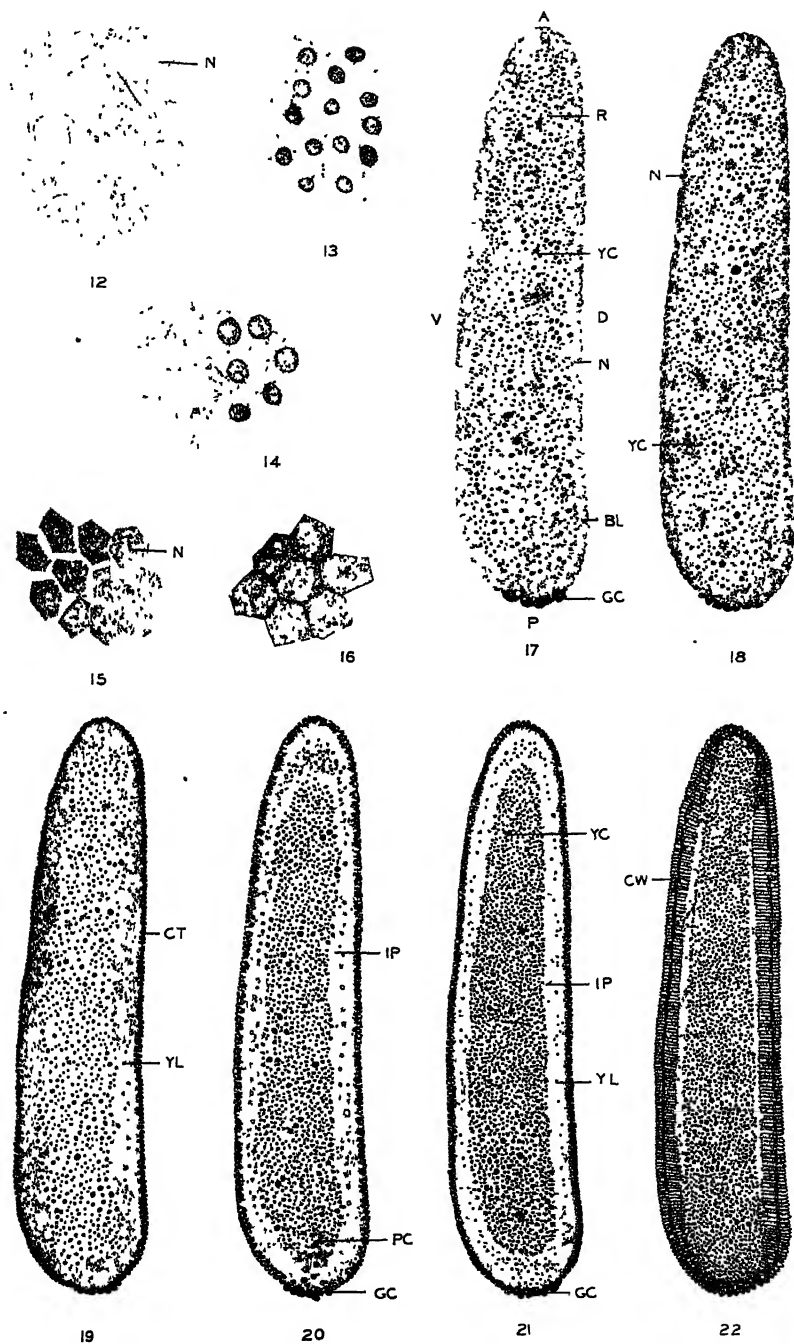
FIG. 18. Age, about 135 minutes. Notice the increase in the number of blastemal nuclei, the position of the yolk cells and the cell territory formation. N—nucleus; YC—yolk cell.

FIG. 19. Age, about 165 minutes. The yolk cells have all but disappeared from the yolk mass. The blastema is now approximately doubled in thickness. Compare this stage to that represented in Pl. I, fig. 7. CT—cell territory; YL—yolk layer.

FIG. 20. Age, about 180 minutes. The yolk mass becomes more dense and the inner periplasm smooths out on its medial surface. Observe, in the posterior pole, the inverted protoplasmic cone with its nuclei. GC—germ cell; IP—inner periplasm; PC—protoplasmic cone.

FIG. 21. Age, about 180 minutes. The blastema is thicker on the dorsal surface. Notice the distribution of the inner periplasmic layer. GC—germ cell; IP—inner periplasm; YC—yolk cell; YL—yolk layer.

FIG. 22. Age, about 215 minutes. The blastoderm is almost completed except for the narrow undivided protoplasmic strip beneath the cells of the dorsal and ventral surfaces. Absorption of yolk by the cells occurs in the polar regions. CW—cell wall.



blastemal layer and at the time of peripheral protoplasmic darkening, the greatest amount of protoplasmic surface is present. Although the amount of protoplasmic surface may not be the chief limiting factor (the chorion and vitelline membrane surround the protoplasmic elements), this increase in surface area, at least five to ten times greater than the undivided blastema, may well be a causative factor in the differential staining properties of the protoplasm, in increasing rates of certain metabolic processes, and in initiating yolk cell migration.

The row of nuclei remains constant in position and the clefts indent past it. Certain of my sections indicate that temporary fusion of the outer borders of the compartments occurs. (Pl. I, fig. 8.) At this time the width of the base of the cell territory is narrower than the width of its outer margins.

Meanwhile the inner border of the blastema has smoothed out and yolk material accumulates at this surface. The outer borders of the cell territories assume a less angular appearance and gradually become rounded. (Pl. I, fig. 10.) Cell walls appear first on the peripheral margin and slowly penetrate the undivided blastema. When they have almost reached the inner border yolk material flows into the cells. (Pl. I, fig. 11.) There is no observable difference in the physical nature of the yolk material after it passes into the cells. It is difficult to determine whether the movement of yolk into the cells occurs first at the anterior or posterior pole. My sections indicate that it occurs first in the posterior pole in the region of the germ cells. As yet there is no cell wall on that portion of the cell in contact with the yolk mass.

So far the development of the blastoderm has been discussed only from a two dimensional viewpoint. In cross section of the cell territories (a tangential section of the egg), the edges of the territories in the earlier stages are somewhat asymmetrical and are widely separated from one another at their outer borders. Some surfaces of the cell are broadly rounded while others of the same cell may be angular. (Pl. II, fig. 14.) As development proceeds a cross section of cell territories, after the cell walls have formed, is similar in appearance to the comb of the honey-bee. (Pl. II, fig. 16.)

The time required for blastodermal development beginning with the nuclear penetration of the periplasm is about one hour and forty-five minutes.

Except for the lack of cell walls on their base, the blastodermal cells are now complete. In comparing this stage with an early blastemal stage the following contrasts are apparent. Instead of a continuous narrow outer layer, the blastoderm has a divided thick outer layer; instead of a yolk mass with yolk particles widely scattered, a yolk mass with elements relatively dense; instead of numerous large amoeboid cells in the yolk mass joined together by a profuse reticulum, a yolk mass with a few degenerate cells joined by a reduced reticulum.

If a series of successive stages in the development of the blastoderm are observed, viewing only a portion of the blastemal layer, a misleading interpretation may result, namely, that the cell territories push outward while the associated structures remain in a relatively fixed position. If this were the case the diameter of the egg would be greatly increased by the time of cell wall formation. Actually, however,

measurements indicate that the egg, exclusive of its membranes, is slightly smaller at the blastodermal stage than at the early blastemal stage.

#### THE YOLK CELLS AND INNER PERIPLASM

As already mentioned, not all of the cleavage cells merge with the periplasm, but some of them, after migrating almost to the periphery, return back into the yolk mass. These cells are here considered yolk cells. Each consists of an irregular mass of cytoplasm frequently indented by yolk particles and usually containing a single nucleus. In *Lucilia sericata* they are numerous and are scattered regularly throughout the yolk mass.

Nelson (1915) classifies yolk cells as primary and secondary. This classification is based only on their time of origin. The primary yolk cells are those which remain behind in the yolk; the secondary cells are those which enter the yolk from the blastoderm during its formation.

Shortly after the cleavage nuclei have penetrated the periplasm numerous yolk cells may be seen lying within the yolk mass. However, this observation is not sufficient to warrant the statement that they are true primary yolk cells, i.e., they are cells that have lagged behind in the yolk. An incomplete series of stages at this period of development may lead to this conclusion. Actually, however, at the exact time of fusion of the cleavage cells with the periplasm no yolk cells can be seen in the yolk mass. All of the cleavage cells migrate towards the periphery where the majority fuse with the periplasm. The remaining cells turn back into the yolk. Thus in the strict sense of Nelson's definition they cannot be regarded as true primary yolk cells. (The writer (1947) called these cells the primary yolk cells.)

To understand more fully the fate of these cells in this species the origin of the inner periplasmic layer must be taken into consideration. Although the evidence presented here is not conclusive it indicates the following conditions: an actual remigration of some yolk cells towards the periphery which help form the inner periplasm, and a partial degeneration of some of them in the yolk. (Pls. II, III, figs. 19, 24.)

It has been pointed out that the width of the blastemal layer is approximately doubled during the blastodermal development. Since there is no extrinsic source of nutritive materials this increase of material must originate by the transfer of substances from within the egg itself.

Simultaneous with the doubling in thickness of the blastema the yolk mass contains only a few cells within it and these appear very different in structure from the yolk cells of the early blastema. The cytoplasm of these cells appears very concentrated and the size of the cells is greatly diminished. In addition to these observations the medial blastemal surface is now extremely irregular and very closely resembles the medial surface of the periplasm at the stage of original fusion of the cleavage cells with the periplasm (Fish, 1947, Pl. VI, fig. 18). Between the medial border of the original blastema and the peripheral border of the now-forming inner periplasmic layer can be found numerous "engulfed" yolk particles. (Pls. II, III, figs. 19, 24.) A similar process of "engulfing" yolk elements was readily observed when the cleavage cells first merge with the periplasm. This occurs,



apparently, when elements of yolk, which have been "pushed" peripherally by the amoeboid cleavage cells, become surrounded when the cells complete their fusion with the periplasm.

Within a period of several minutes the medial irregular boundary of the newly formed layer gradually smoothes out. The egg, in most regions, may now be divided into four distinct zones. Proceeding from the outside there is (1) an outer layer, the blastema, consisting of two definite areas, the divided or cellular portion and the undivided or continuous portion, (2) a layer of yolk material, narrowest on the dorsal surface and widest at the anterior pole, (3) a second protoplasmic layer, the inner periplasm and (4) the main yolk area. (Pls. II, III, (figs. 21, 25.)

In regard to the distribution of the inner periplasm among the muscids, there are various interpretations by different authors. According to Weisman (1863), the inner periplasm is a uniformly thick layer under the entire blastoderm. Graber (1889) has stated that this layer exhibits no uniform arrangement. Noack (1901) however, states that these two views are incorrect. Briefly he describes the inner periplasm as being present only in the anterior pole and in the dorsal and ventral regions; its distribution is not uniform but is thickest in the dorsal region.

Assuming that the development of the inner periplasm does not vary markedly in different species of Calliphoridae, then my observations on *Lucilia sericata* are essentially in agreement with Noack's on *Calliphora erythrocephala*. There are, however, several points of difference. My sections show that the inner periplasm may also be developed in the posterior pole. (Pl. II, fig. 21.) This region of the inner periplasm is not as clearly outlined as that of the anterior pole chiefly because of the comparatively great amount of yolk elements scattered within the protoplasm in this area. In addition, not all individuals even from the same parents, develop the inner periplasm in precisely the same manner. In exceptional cases, even after the inner periplasm was completely developed, no difference in its thickness on the ventral or dorsal surface was detected.

As concerns the fate of the inner periplasm, it fuses with the original blastemal layer, becomes divided by the cell walls and thus enters into the cytoplasmic makeup of the individual cells.

#### EXPLANATION OF PLATE III

Figures 23-26 are drawn under 264X and detailed under 950X.

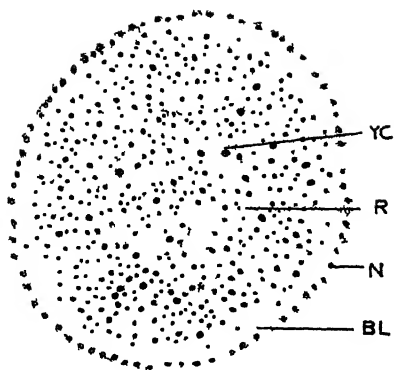
FIG. 23 Age, about 120 minutes. Cross-section taken at level X, Pl. II, fig. 18. BL—blastema; N—nucleus; R—reticulum; YC—yolk cell.

FIG. 24 Age, about 165 minutes. Cross-section at level X, Pl. II, fig. 19. Notice the disappearance of the large yolk cells and the doubling in thickness of the blastema. YC—yolk cell.

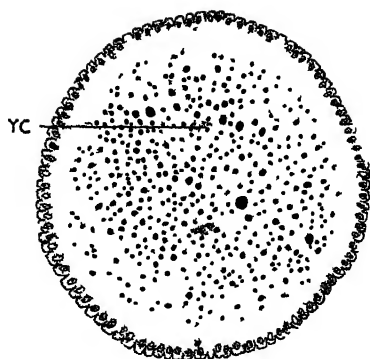
FIG. 25 Age, about 180 minutes. Cross-section at level X, Pl. II, fig. 21. BL—blastema; IP—inner periplasm; Y—yolk; YL—yolk layer.

FIG. 26 Age, about 180 minutes. Cross-section at level X, Pl. II, fig. 20, about thirty microns from posterior pole, showing germ cells and inverted protoplasmic cone. GC—germ cell, PC—protoplasmic cone.

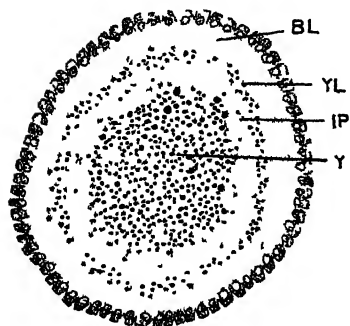
FIG. 27. Age, about 180 minutes. A longitudinal section of the protoplasmic cone showing the germ cells and cone nuclei. Drawn under 950X and detailed under 1450X. DN—degenerating nucleus, GC—germ cell



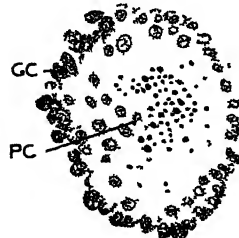
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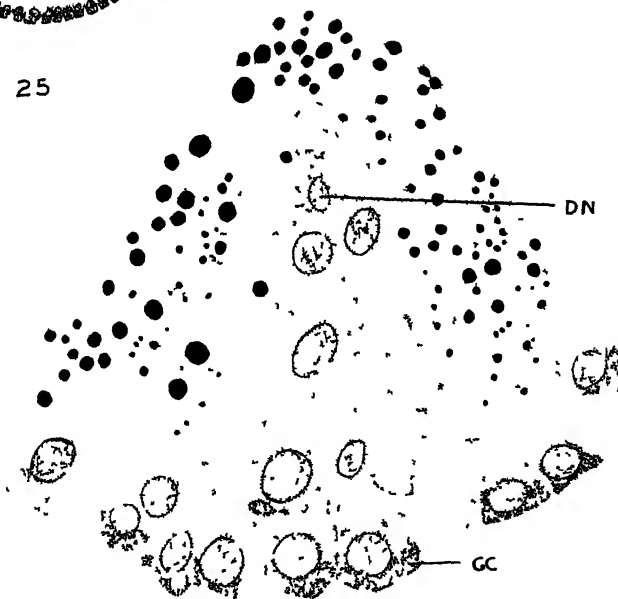
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While these changes are occurring the protoplasmic reticulum of the yolk mass, already diminished by the migration of the cleavage cells, undergoes still greater diminution. Whether it is transferred directly to the blastema by yolk cell migration, whether it is absorbed in the yolk mass and later reformed in the inner periplasm or whether absorption occurs without reformation was not observed. In view of the fact that a part of the reticular protoplasm was transferred to the periplasm with the cleavage cells in their migration, it would then appear that a similar transfer of reticulum might occur when the yolk cells migrate towards the blastema.

#### THE GERM CELLS

To avoid repetition, since the subject of germ cells in muscids has already been described with uniformity by various authors, and notably Noack (1901) and Auten (1934), the discussion following will be brief and of a general nature. My observations are in close agreement with those reported by the above mentioned authors.

On the dorsal surface of the egg, in the periplasm of the posterior pole, is a darkly-staining diffuse inclusion, the oösome or germ cell determinant. Noack describes this inclusion as rod-like. However, in agreement with Auten, the germ cell determinant in this species consists of a relatively wide band of granular material.

As the cleavage cells penetrate the dorsal surface of the posterior pole they break up and absorb this inclusion and appear as darkly stained cells protruding slightly from the polar surface. Exactly how many cells initially break up this inclusion I cannot say with certainty except that it is more than one (probably seven to ten).

The ensuing development is relatively easy to follow up to the time where the blastodermal cells become peripherally darkened. Although the blastodermal cells are for the most part columnar, those in the curvature of the poles appear rounded. For this reason it is almost impossible to accurately detect the limits of the germ cells from those of the blastodermal cells. In general the rate of increase in numbers of these two types of cells is about the same.

Perhaps the most interesting phenomenon associated here is the development of an inverted protoplasmic cone in the posterior dorso-polar area. (Pls. II, III, figs. 20, 26, 27.) This development occurs at the same time as the formation of the inner periplasm. Some of the germ cell nuclei (and perhaps blastodermal cell nuclei) migrate from their peripheral position into this cone. In one cone I have counted nine of these nuclei, two of which showed signs of degeneration. (Pl. III, fig. 27.)

As concerns the fate of this cone and its nuclei, I am uncertain. From all appearances it rapidly degenerates for it is not evident during the later stages of the development of the blastoderm. Noack states that this cone gives rise to yolk cells.

#### SUMMARY

1. There is no observable difference in the developmental rates of the anterior and posterior poles during the formation of the blastoderm.

2. The blastema is divided into cell territories by clefts which appear peripherally, and gradually penetrate the blastema.

3. The blastema approximately doubles in thickness by the addition of the inner periplasm. The latter probably has a twofold origin: (a) by the fusion of yolk cells which have migrated towards the periphery, (b) the transfer of protoplasmic reticulum from the yolk area.

4. The inner periplasm is present dorsally, ventrally and in both poles of the egg.

5. *Lucilia sericata* possesses no true primary yolk cells; that is, none of the cleavage cells remain "in situ" in the yolk.

6. Yolk material flows into the blastodermal cells when the cell walls are almost in contact with the yolk.

7. The enormous increase in the protoplasmic surface may be a causative factor in yolk cell migration and other associated phenomena.

8. The germ cell determinant inclusion is not rod-like but a relatively large diffuse mass of granules.

9. The rate of germ cell formation closely parallels the rate of blastodermal cell development.

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#### CHECKLIST OF THE COLEOPTEROUS INSECTS OF MEXICO, CENTRAL AMERICA, THE WEST INDIES, AND SOUTH AMERICA, Part 5, by RICHARD E. BLACKWELDER. iv+765-925 pages, 1947. United States National Museum, Bulletin 185.

With the appearance of part 5 it was expected that the completion of this extensive list could be announced, but it proves to be the completion of the checklist only. An additional part is promised to include the bibliography and an index to the genera and higher categories.

Continuing the format of the preceding parts, this one includes the families Anthribidae, Brentidae, Scolytidae, Coptonotidae, Platypodidae, Curculionidae and Cerasomatidiidae, and as an addendum to page 270, the family Chelonariidae.

Since the Checklist includes the geographic distribution of the species and a cryptic reference to each original description, the appearance of the final part should extend its value to coleopterists far beyond the usual limits of such lists.

—A. W. L.

# DIFFERENCES IN THE OCCURRENCE OF NYMPHS OF TWO SPECIES OF BURROWING MAYFLIES IN FISH STOMACHS<sup>1</sup>

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In many of the lakes of southern Michigan two species of burrowing mayflies, *Ephemera simulans* (Say) and *Hexagenia occulta* (Walker)<sup>2</sup> are quite abundant. Bottom samples taken in these lakes by survey parties from the Michigan Institute for Fisheries Research have frequently revealed dense concentrations of nymphs and have shown that the two species often occur together, sometimes appearing in approximately equal numbers in a given Ekman or Peterson dredge haul.

The habits of nymphs of the two species have been little studied in nature. In particular, the depth to which they generally burrow, and the possibly different levels of the substrate which they may occupy at different times of day and night, have not been established. Ide (1935) found that burrowing nymphs of *Ephoron leukon* inhabiting stony riffles of an Ontario stream had the habit of "... avoiding light during the day in the deeper part of the tube and coming up to the open end in the evening to feed." In a sand-bottom trout stream in Montmorency County, Michigan, where *Hexagenia recurvata* is abundant, the writer has seldom found the nymphs less than four inches below the surface of the stream bed.

The rate of occurrence of burrowing mayfly nymphs in fish stomachs may offer certain clues to their habits. It is commonly thought by fishery biologists that the diet of fishes in lakes and streams is determined largely by what potential food organisms are available to the fish. Forbes (1888) found that nymphs of *Hexagenia* (species undetermined) composed about one-tenth of the total food of many fishes from Illinois waters examined by him. Neither he nor various workers who have reported *Hexagenia* nymphs from fish stomachs in more recent years have supplied adequate information as to the season when their specimens were taken, although Neave (1932), after stating that nymphs of *H. occulta* were a very important food for sturgeon, whitefish, tullibee, goldeye and sauger in Lake Winnipeg, inferred that they were important the year around when he wrote "... owing to the limited season during which they [the winged phases] are available and because most of the marketable fish are bottom feeders, their direct importance as a food supply is negligible as compared with the nymphal stages." Little has been reported of the occurrence of *Ephemera* nymphs in fish stomachs although Ricker (1934), referring to a form listed by him as "*Ephemera* cf. *simulans*," stated that it was "found [in brook trout

<sup>1</sup>Contribution from the Michigan Institute for Fisheries Research.

<sup>2</sup>The form listed by Spieth (1941) as *Hexagenia limbata occulta* (Walker); the name used here follows Needham, Traver and Hsu (1935).

stomachs] throughout the year; excessively abundant at time of emergence."

In Birch Lake, an oligotrophic lake in southwestern Michigan, both *E. simulans* and *H. occulta* are plentiful. In connection with a fisheries management experiment, a series of 322 stomachs of rainbow trout (*Salmo gairdnerii irideus* Gibbons) 7 $\frac{5}{8}$  to 22 $\frac{1}{2}$  inches in length was collected from Birch Lake over a six-year period embracing a seasonal span of 31 weeks, from May 21 to December 19. Except for a few

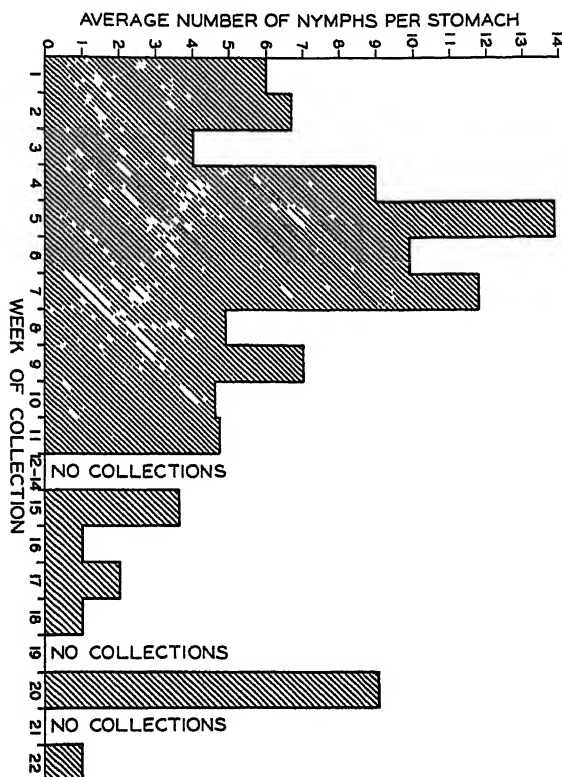


FIGURE 1. Histogram showing average number of *Hexagenia occulta* nymphs per stomach in rainbow trout stomachs containing the species, collected over a 22-week period, June 25 to November 20.

specimens taken in gill nets, all the fish were caught by anglers and the stomachs collected by a biologist acting as creel census clerk. Analysis of the contents of these stomachs revealed a striking disparity in the frequency of occurrence of the two species of ephemerines. *Ephemera simulans* appeared on only six dates: May 23, June 25 and 27, July 30, and August 2 and 3. Stomachs of trout taken on May 23, when a mass emergence of *simulans* took place, averaged 507 nymphs and 106

subimagos per stomach, one 18-inch rainbow containing 789 nymphs and 232 subimagos. In collections made on the other dates, *simulans* nymphs occurred in single stomachs at an average rate of three per stomach. By contrast, *Hexagenia occulta* nymphs were of steady occurrence in stomachs throughout the entire period covered by col-

TABLE I

AQUATIC INSECTS APPEARING IN THE DIET OF RAINBOW TROUT COLLECTED FROM BIRCH LAKE, CASS COUNTY, MICHIGAN, OVER A SIX-YEAR PERIOD AND A SEASONAL SPAN OF 31 WEEKS FROM MAY 21 TO DECEMBER 19.

An asterisk (\*) denotes values less than one-half of one percent.

SPECIES <sup>1</sup>	Average number of organisms in stomachs containing them	Percent of stomachs containing organism	Percent of total volume of aquatic insects	SPECIES	Average number of organisms in stomachs containing them	Percent of stomachs containing organism	Percent of total volume of aquatic insects
EPHEMEROPTERA.....		66	77	COLEOPTERA (cont'd)			
<i>Ephemera simulans</i> .....	274.0	3	(29)	Gyrinidae.....	1.0	1	.....
<i>Hexagenia occulta</i> .....	7.0	64	(48)	Hydrophilidae.....	1.0	1	.....
<i>Ephemerella temporalis</i> .....	4.7	1	.....	Dryopidae.....	1.0	1	.....
Baetinae.....	1.0	2	.....	<i>Donacia</i> sp.....	2.0	1	.....
<i>Callibaetis</i> sp.....	1.0	0	.....	TRICHOPTERA.....		23	14
ODONATA.....		9	1	Hydroptilidae.....	1.9	5	.....
Coenagrioninae.....	1.0	4	.....	<i>Oxyethira</i> sp.....	1.2	2	.....
<i>Enallagma</i> spp.....	1.7	3	.....	<i>Banksiola selma</i> .....	21.0	1	.....
<i>Amphiagrion saucium</i> .....	1.0	1	.....	<i>Phryganea</i> cf. <i>cinerea</i> ...	11.2	6	.....
<i>Neogomphoides obscura</i> .....	1.0	*	.....	Lamnephilidae.....	1.0	1	.....
<i>Stylurus</i> sp.....	2.0	*	.....	<i>Leptocella exquisita</i> .....	1.5	1	.....
<i>Epicordulia princeps</i> .....	1.0	*	.....	<i>Leptocella albida</i> .....	4.0	6	.....
<i>Tetragoneuria simulans</i> ..	1.0	1	.....	<i>Oecetis</i> sp.....	1.0	1	.....
<i>Libellula</i> sp.....	1.1	2	.....	<i>Oecetis edlestoni</i> .....	1.0	*	.....
<i>Plathemis lydia</i> .....	1.0	*	.....	<i>Tricnoides tarda</i> .....	1.0	*	.....
NEUROPTERA.....		8	1	<i>Tricnoides injusta</i> .....	2.0	*	.....
<i>Stalis infumata</i> .....	2.5	8	.....	<i>Mystacides</i> sp.....	2.0	1	.....
PLECOPTERA.....		*	*	<i>Mystacides sepulchralis</i> ..	1.0	1	.....
<i>Isoptera</i> sp.....	1.0	*	.....	<i>Brachycentrus</i> sp.....	1.0	1	.....
HEMIPTERA.....		2	*	DIPTERA.....		77	6
<i>Arctocoris</i> sp.....	1.5	2	.....	<i>Tipula abdominalis</i> .....	1.0	1	.....
<i>Notonecta undulata</i> .....	1.0	*	.....	Chironomidae <sup>2</sup> .....	12.5	76	.....
<i>Belostoma fumineum</i> ....	1.0	*	.....	Ceratopogonidae.....	5.2	7	.....
COLEOPTERA.....		6	1	<i>Culex</i> sp.....	1.0	1	.....
<i>Haliphus</i> sp.....	1.0	*	.....	<i>Chaoborus punctipennis</i> ..	1.0	*	.....
Dytiscidae.....	1.0	1	.....	<i>Simulium venustum</i> ....	1.0	*	.....

<sup>1</sup>All species in immature stages except: *Ephemera simulans*, both nymphs and subimagos; all Hemiptera, adult; *Haliphus* sp. and *Donacia* sp., adult; *Tipula abdominalis* and *Culex* sp., larvae and adults.

<sup>2</sup>Included *Polyptilum nubeculosum*, *Tanytus stellatus*, *Tanytarsus dimorphus*, *Chironomus plumosus*, *obiferus* and *modestus*.

lections. They first appeared in trout caught on June 25; their occurrence during the ensuing 26-week span, summarized by weekly intervals, is shown in figure 1. It will be seen that subimaginal and adult specimens were not eaten, although some of the nymphs taken in June appeared to be mature, the females with well developed eggs. Failure of the trout to feed on either of the winged stages is probably explained

by the fact that in southern Michigan *occulta* seldom emerges before late June and early July, when the surface waters of the lake are generally so warm as to repel trout. It should be stated, in this connection, that terrestrial insects were of very rare occurrence in the stomachs except during October and early November.

On a volumetric basis, the rainbow trout diet in Birch Lake was made up of the following major categories of food items: fish, 43 per cent; aquatic insects, 23 per cent; vegetable matter, 6 per cent; mollusks, decapod crustaceans and terrestrial insects (87 species of the last-named), 3 per cent each. The remaining 19 per cent was composed of unseparated organic debris and of negligible numbers of entomostracans, water mites and spiders. The aquatic insect portion of the stomach contents is detailed in Table I. The catholicity of a diet so comprehensive as to embrace 170 species of invertebrates alone makes it appear likely that the rainbow trout is almost wholly opportunistic in its feeding. It seems obvious that throughout all seasons nymphs of *H. occulta* in Birch Lake were so readily available to the trout as to almost equal, in the diet, the volume of all other aquatic insects combined, whereas, with minor exceptions, nymphs of *E. simulans* became available only during the brief period of their migration to the lake's surface to transform. The fact that *H. occulta* appears to have a two-year life cycle and *E. simulans* an annual cycle in southern Michigan cannot explain the disparate occurrence of the two species, for stomach collections made over a period of six years and a seasonal span of seven months were examined. In the absence of recorded observations on the behavior of nymphs of the two species in their natural habitat it appears justifiable to conclude that *E. simulans* spends its nymphal life too deeply embedded in the substrate to be available to bottom-feeding rainbow trout and that *H. occulta* nymphs, on the other hand, either leave their burrows occasionally or at least come near enough to the surface of the lake bottom to fall a consistent prey.

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# NEW NORTH AMERICAN BEES OF THE GENUS DUFOUREA

(Apodea: Halictidae)

## PART I

GEORGE E. BOHART,

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The number of known species of North American *Dufourea* has increased rapidly in recent years. In 1937 C. D. Michener<sup>1</sup> raised the number of valid described species from 20 to 26. P. H. Timberlake in 1939<sup>2</sup> and 1941<sup>3</sup> added 14 species. T. D. A. Cockerell<sup>4</sup> in 1941 added one from Lower California. The following seven new species plus eight more which will be described in the next paper of this series, will bring the total number of species to 56.

Males of all species of *Dufourea* can be readily recognized. Facial measurements, antennal proportions and pubescence, and modifications of the legs and sternites present the most striking characters. Females conform rather closely to a common pattern and in related species they are often difficult to separate. For a few pairs of related species no consistent characters of differentiation have been found.

The following descriptions have been made rather detailed in view of the large number of species in the genus and the lack of any adequate system of subgenera. Moreover, it is hoped that the species herein described may be recognized for the present without complete tables for separation and that the characters described will serve as guides for further studies in the genus.

Holotypes and allotypes of species described in this paper will be deposited at the California Academy of Sciences in San Francisco. Paratypes will be distributed to the following collections besides the author's: U. S. National Museum; U. C. Citrus Experiment Station, Riverside, California; American Museum of Natural History, New York. When available, paratypes will be sent to other collections upon request.

### *Dufourea gilia* n. sp.

*Male*.—Length about 6 mm., length of anterior wing 3.4 mm.; pubescence wholly pale, mostly white; integument dark with bluish reflections distinct only on head. *Head*: Face length to breadth 95–90; eyes distinctly convergent below, the distance between them at antennal insertion slightly less than eye length; face viewed from front with distance behind posterior ocellus nearly equal to ocellar diameter; no concavities behind or laterad to ocelli; distance from antennal socket to clypeus one half again as great as socket diameter; clypeus, supra-

<sup>1</sup>Ann. & Mag. Nat. Hist. (10) 19, pp. 328 and 393–401.

<sup>2</sup>Ann. Ent. Soc. Amer. 32, pp. 395–414.

<sup>3</sup>Ann. Ent. Soc. Amer. 34, pp. 38–42.

<sup>4</sup>Trans. San Diego Soc. Nat. Hist. 9, p. 347.

clypeal area concealed by dense, white, reclining pubescence; punctures of frons moderately fine, close, mostly little less than one puncture width apart, absent from area laterad to posterior ocellus; antennae black, as long as anterior wing, flagellar segments mostly about half again as long as broad, the first three-fourths as long as second, all entirely roughened, slightly expanded medially and with many pale, hooked hairs about half as long as flagellar width and confined to under side but not to definite rows; scape a little over twice as long as broad, with long inner and short outer hairs; maxillary stipes one seventh longer than hind tibia, the galea beyond palpus nearly four times as long as broad, apically attenuate; maxillary palpus longer than hind tibia, the second segment nearly twice as long as first and as long as next three combined; labial palpus three-fourths as long as maxillary, the first segment equal to next two combined. *Thorax*: Mesoscutum and mesoscutellum strongly, moderately closely punctured, the punctures mostly a little more than one puncture width apart; area between punctures polished; mesoscutal hair both long and short, not at all concealing integument; mesoscutellar pubescence dense and mostly about as long as scape; wings definitely yellow-tinged, first transverse cubital vein offset from first recurrent by two-thirds its own length; legs not highly modified; femora slightly swollen, fore and mid ones broadest near base, the former with hair fringe longer than scape; hind tibia decidedly swollen beyond middle, over one-third as broad as long, swollen portion with pubescence two-thirds as long as tibia; mid tibia strongly swollen near apex where it is twice as broad as at base, and with outer face covered by long, dense pubescence; hind metatarsus parallel-sided, nearly four times as long as broad, the succeeding three segments about as broad as long. *Propodeum*: Enclosure coarsely rugo-carinate throughout, with about 12 rugae on either side of mid line. *Abdomen*: Tergites finely, sparsely punctate, first segment mirror-like but with rather numerous scattered punctures on middle half; apical fascia long, complete on apical four segments but not so dense as in *tuolumne*; last three tergites with numerous scattered white hairs between fascia, lateral pubescence of sixth longer than the segment; sternites without lateral hooklets; fifth emarginate apically, the emargination broadly truncate medially, mid line swelling almost imperceptible; sixth with median elevated ridge very similar to that of *tuolumne*; posterior arms of seventh slender, narrowly rounded apically, with short hair; apical projection of eighth slender but broadened in profile.

*Female*.—Length about 5 mm.; length of anterior wing 4 mm.; pubescence whitish, somewhat tinged with yellow on dorsum of thorax; integument black, with feeble bluish reflections on frons; body robust. *Head*: Face nine-tenths as broad as long; inner eye margins parallel, distance between them at antennal insertions equal to eye length; distance from antennal socket to clypeus greater than socket diameter; face, viewed directly from front, with postocellar length less than ocellar diameter; anterior face of clypeus with about 30 coarse punctures, most of them sublateral; hair of clypeus sparse, semi-erect, that of supraclypeal area dense, reclining; frons with numerous short hairs visible mainly in profile; frons evenly convex, with punctures about one

puncture width apart except for impunctate area laterad to posterior ocellus; antennal flagellum black. *Thorax*: Dorsum rather dull, strongly punctured, the punctures generally not more than one puncture width apart; mesoscutum with only very short yellowish pile, conspicuous in lateral aspect; mesoscutellum and metanotum largely obscured by dense, yellowish hair; hind wing with 5 hamuli; apical bristles of fore tibia testaceous; mid tibial spur testaceous to whitish; tibial scopa moderately dense, whitish, the hairs somewhat appressed. *Propodeum*: Enclosure coarsely rugo-carinate (crinkly), with strong posterior transverse carinae. *Abdomen*: Tergites with fine, mostly setigerous punctures, the first segment mirror-like but with several hundred tiny punctures on dorsal disk; whitish apical borders of tergites three and four with complete but not dense hair bands; basal hair border of tergite three complete, well defined; anal fimbria reddish testaceous.

*Holotype* male, *allotype*, 3 male *paratypes*: 16 miles east of Mt. Hamilton, Santa Clara Co., California, April 20, 1947, from *Gilia* (G. E. Bohart).

The only variation noted in the series was a slight increase in the density of the abdominal hair bands over the holotype.

This species is very close to *D. tuolumne* new species but has a decidedly longer face in both sexes and more dilated hind tibia and metatarsus in the male.

#### *Dufourea tuolumne* n. sp.

*Male*.—Length about 5 mm., length of anterior wing 3.1 mm.; pubescence wholly pale, mostly white; integument dark with bluish tints, especially on head. *Head*: Face slightly broader than long; eyes rather strongly converging below, distance between them at antennal insertion no greater than eye length; face, as viewed directly from in front, with distance from posterior ocellus to posterior vertex margin negligible, less than half an ocellar diameter; no concavities behind or laterad to ocelli; distance from antennal socket to clypeus slightly greater than socket diameter; clypeus, supra-clypeal area concealed by dense, white, reclining pubescence; punctures of frons moderately fine, close, mostly a little less than one puncture width apart, absent from small area just altered to posterior ocellus: antennae black, long, reaching at least to metanotum, the flagellar segments mostly a little more than half as broad as long, entirely roughened, non-crenulate, the second slightly longer than first or third, all segments with more than ten (many with more than twenty) pale hooked hairs, less than half as long as flagellar width, confined to under side but not to definite rows; scape slightly more than twice as long as broad, inner hairs long, outer ones short; maxilla with stipes shorter than posterior tibia, no longer than eye; galea three times as long as broad, pointed apically; maxillary palpus over half as long as stipes, first segment not more than three times as long as broad, three-fourths as long as second, both together longer than next four (which are sub-equal) together; labial palpus nearly as long as maxillary, first segment five times as long as broad, longer than succeeding two together, second slightly longer than fourth, nearly twice the third. *Thorax*: Mesoscutum strongly, moderately closely punctured, the punctures mostly about or a little more than

one puncture width apart mesoscutellum more densely punctate; area between punctures shining, non-reticulate; mesoscutum with rather sparse, fine, wholly white hair never concealing integument, often moderately long; metanotum, mesoscutellum with dense pubescence as long as antennal scape; wings clear, faintly clouded with yellow, first transverse cubital vein offset from first recurrent by its own length; legs not conspicuously modified; femora slightly swollen, about twice as long as broad, anterior, middle ones broadest near base, the former with fringe of hairs nearly as long as femur; fore, mid tibiae with short, uniform pubescence, hind one swollen just beyond the middle, less than three times as long as broad, with fringe of hairs sometimes longer than tibia; fore basitarsus with very long hairs, longer than itself, mid basitarsus distinctly arcuate, with similar hair fringe to fore one; hind basitarsus three times as long as broad, succeeding two segments longer than broad, penultimate one broader than long. *Propodeum*: Enclosure coarsely rugo-striate, medially rugose with about eight comparatively distinct acrinae on either side of mid line, the sculpturing no weaker posteriorly. *Abdomen*: Tergites sparsely, finely punctured, numerous but separated by several puncture widths because of their minute size, sparsest on first tergite; all tergites with distinct, long, apical fasciae, the basal two strong laterally only, those of fourth, fifth tergites, when abdomen is not extended, nearly half as long as visible sternite portions; tergites with white hair between fasciae, prominent laterally on last three; sternites without lateral hooklets; fifth sternite slightly raised along mid line, emarginate apically, the emargination truncate medially; sixth sternite with median, longitudinal, colorless transparent, elevated area, broadest sub-basally, narrowing, increasing in height posteriorly, forming a terminal, sharp ridge running along mid line of the short, flat sternite projection; posterior arms of seventh narrowed most of their length, apically acute, with hairs confined to apices, basal ventral flaps considerably broader than long; apical process of eighth sternite broadest just basad to middle, narrow for apical third, slightly expanded at apex to one-half greatest breadth, hairs of base of narrow portion three times as long as at apex.

*Female*.—Length about 5 mm., length of anterior wing 3.8 mm., pubescence white to pale brown, short, abundant; integument black with metallic bluish tinge on head, slight purplish copper tinge on mesoscutum; body robust. *Head*: Face slightly less than six-sevenths as long as broad; inner eye margins nearly parallel, slightly converging below, their length not quite so great as distance between them at antennal insertion. Face, as viewed directly from in front, with distance from a posterior ocellus to posterior vertex margin not more than half an ocellar diameter; distance from antennal socket to clypeus nearly as great as socket diameter; clypeus uniformly but very sparsely, coarsely punctate, fringed basally with pale brown hairs; frons strongly convex in profile, uniformly covered with fine, short pubescence, dense but not distinct except in profile, surface very uniformly punctate, the punctures moderately strong, separated by distinctly less than one puncture width; antennal flagellum black. *Thorax*: Mesoscutum dull, finely, rather closely punctured, the punctures much as on frons, a little finer, denser anteriorly; mesonotum densely covered with very short,

fine, pale brownish hair, conspicuous only from lateral view, these interspersed with a few darker brown hairs as long as an ocellar diameter; apical bristles of fore tibia testaceous; mid tibial spur testaceous to whitish, apical two fifths with about eight needle-like teeth, basal portion apparently edentate; tibial scopa moderately dense, pale brownish, hairs mostly somewhat appressed. *Propodeum*: Enclosure coarsely, irregularly rugose, rugae becoming straighter laterally. *Abdomen*: Tergites with fine punctures, mostly setigerous, except on first where they are typically punctiform but very thin, separated by several puncture widths; apical tergite borders testaceous; hair distinct, whitish, nearly complete, often nearly concealing impunctate tergite borders; remainder of tergum with pale, short hair, conspicuous as viewed laterally; anal fimbria bright testaceous. *Holotype*: Tuolumne Co., California, elevation 3500 ft., June 9, 1938, from *Linanthus filipes*, (R. M. Bohart). *Allotype*: Same as for holotype. *Paratypes*: 38 males, 15 females, same data as for holotype (some collected by N. F. Hardman). Very little variation is observable. The closeness of mesoscutal punctures is slightly but not significantly variable.

This species is related to *californica* (Mich.) and *linanthi* Timb. It can be easily distinguished by the high carina of the sixth sternite and the arcuate mid basitarsus of the male.

**Dufourea vanduzeei n. sp.**

*Male*.—Length about 6 mm.; length of anterior wing 3.4 mm.; pubescence wholly pale, mostly white; integument dark with bluish reflections distinct on head, almost imperceptible on thorax; body slender. *Head*: Face nine-tenths as long as wide; eyes rather strongly converging below, the distance between them at antennal insertions a little less than eye length; face, viewed from in front, with postocellar distance subequal to ocellar diameter; areas behind and laterad to ocelli without concavities; distance from antennal socket to clypeus slightly less than socket diameter; clypeus, and to lesser extent supra-clypeal area concealed by dense, white, reclining pubescence; punctures of frons rather fine and sparse, averaging at least two puncture widths apart, absent from crescentic area just laterad to posterior ocellus; antennae blackish, as long as anterior wings, the terminal 5 segments distinctly lobate, the others less so; under sides of flagellum with very numerous tiny erect hairs bent at the tips and conspicuous in profile compared to the minute reclining pubescence of the "bare" remainder; first flagellar segment a little longer than broad, over two-thirds as long as second, two-thirds as long as third which is nearly twice as long as broad; scape three times as long as broad, mostly parallel sided; maxillary stipes three-fourths as long as posterior tibia, the galea beyond palpus half as broad as long; maxillary palpus three-fifths as long as stipes, segments one and two subequal, each as long as segments three, four and five combined; labial palpus about four-fifths as long as maxillary, the first segment subequal to the others combined. *Thorax*: Mesoscutum strongly but not closely punctured, the punctures averaging about two puncture widths apart; interpunctural areas subshining, slightly reticulate; mesoscutum rather densely covered with long yellowish pubescence, partially obscuring the integument in lateral view;

mesoscutellum and metanotum more densely clothed with longer hair of the same color; wings faintly yellowish, the first transverse cubital vein offset from first recurrent by two-thirds its own length; legs slender; metatarsi parallel sided, from four to six times as long as broad; hind tibia four times as long as broad, polished, with hair of dorsal margin nearly as long as tibial breadth; second and third hind tarsal segments longer than broad; hair of hind metatarsus about as long as tarsal width.

*Propodeum*: Enclosure coarsely rugo-carinate, about 10 major carinae on either side of mid line; posterior margin of enclosure with a single transverse ridge. *Abdomen*: Tergites with fine but numerous punctures; apical hair bands well defined, complete on all segments; tergal pubescence otherwise abundant, yellowish, partially obscuring integument from lateral view; first five sternites without hooklets but with well defined postero-lateral hair bands; apex of sternite five evenly emarginate; sternite six with a broad oval median glabrous plate produced apically into a keel-like projection which is also produced from the posterodorsal margin of the sternite; posterior arms of sternite seven broad, flat, nearly pointed apically with long, dense terminal hair tufts; posterior projection of sternite eight slender throughout, nearly as broad at apex as at base. *Holotype* male and *paratype* male: Bryson, Monterey Co., California, May 19, 1920 (E. P. Van Duzee); also one damaged male (abdomen missing) with the same collecting data. The holotype has part of the ventral margin of the projection on sternite six and the inner margins of the arms of sternite seven chewed away (presumably by psocids). Otherwise it checks in detail with the paratype.

This species appears to be in the *D. californica* Michener group and falls closest to *D. tuolumne* new species but is easily distinguished by its larger size, broader median plate on the sixth sternite; shorter face, and more slender legs.

#### *Dufourea neocalifornica* n. sp.

*Male*.—Length about 7 mm.; length of anterior wing 5 mm.; integument dark with dark blue and some coppery reflections; pubescence pale, mostly white. *Head*: Face four-fifths as long as wide; eyes rather strongly converging below, their length a little shorter than distance between them at antennal insertions; face, viewed from in front, with postocellar distance about half an ocellar diameter; area between eyes and posterior ocellus not depressed; distance from antennal socket to clypeus greater than socket diameter; clypeus closely punctate, concealed by dense, reclining pubescence; supra-clypeal area bare (perhaps abraded), polished, practically impunctate; frons densely punctate except along inner eye margins and laterad to posterior ocelli, mostly less than one puncture width apart; antennae black, long, at least four-fifths as long as anterior wing, most of the segments distinctly lobate; scape about twice as long as wide; first flagellar segment two thirds as broad as long, three-fourths as long as second which is slightly longer than succeeding segments except terminal one; under side of flagellum rather flat, bearing mat of numerous short hooked hairs, over 20 on most segments and about one-third as long as flagellar width; maxillary stipes about three-fourths as long as posterior tibia; galea beyond palpus slightly more than twice as long as broad, almost pointed apically;

maxillary palpus three-fourths as long as stipes, first segment four-fifths as long as second, the two together as long as next four combined; labial palpus five-sixths as long as maxillary, the first segment three-fourths as long as next three combined. *Thorax*: Mesoscutum closely, strongly punctured, the punctures less than one puncture width apart, the interpunctural areas shining; mesonotum rather densely clothed with long yellowish pubescence, somewhat obscuring integument from lateral view; wings faintly yellowish, the first transverse cubital vein offset from first recurrent by slightly over half its own length; legs rather stout but not strongly modified; femora about twice as long as broad; hind tibia nearly one-third as broad as long, broadest just beyond middle, with hairs of inner margin not longer than tibial width; mid metatarsus depressed above near base; hind metatarsus half as long as tibia, two-fifths as broad as long, the next two segments produced dorsally, broader than long. *Propodeum*: Enclosure coarsely, evenly carinate, a straight line drawn transversely across the middle cutting about twenty-five carinae. *Abdomen*: Tergum shining but with numerous well defined punctures; tergite one with at least 100 well defined punctures on disk; apical hair bands white, well defined, contrasting strongly with remaining short brown tergal pubescence; sternum shining, with only minute pubescence, lacking hair bands except at corners; sternite five slightly elevated medially and rounded apically; sternite six with a triangular projection a little longer than broad, bearing a median ridge with a strong apical summit, the projection glabrous except for a short stiff lateral fringe; posterior arms of sternite seven evenly tapered, narrowly rounded apically; apical projection of sternite eight slender, with tip about twice as broad as narrowest part and less than half as broad as broadest part.

*Holotype* (unique): Sequoia National Park, California, elevation 2000-3000 ft., May 1930 (collector unknown).

This is very close to *D. californica* (Michener) but differs by having a pronounced apical summit on the projection of the sixth sternite and lacking a pair of strong sublateral hair tufts on the same segment.

#### *Dufourea tarsata* n. sp.

*Male*.—Length (abdomen extended) about 9 mm., length of anterior wing 5.2 mm., pubescence wholly whitish; integument dark, with distinct metallic bluish tint to head, thorax, dorsum of abdomen. *Head*: Face as long as broad; eyes converging slightly below, distance between them at antennal insertion about equal to eye length; face viewed from front with distance from posterior ocellus to vertex margin somewhat greater than ocellar width; area laterad to posterior ocellus shallowly concave; distance from antennal socket to clypeus about equal to socket diameter; clypeus with erect, white pubescence long basally, grading down to short apically, except for marginal fringe; supra-clypeal area bare except for sparse lateral tuft; punctures of frons fine, rather dense laterally, very sparse medially and just laterad to ocelli; area enclosed by subantennal sutures entirely impunctate; antennae black, short, non-crenulate, ventrally flattened, basally swollen; basal two flagellar segments slightly cupped beneath, with dense curled pubescence, the remaining segments with ventral surfaces bearing rather dense mats of

curled hairs mostly about as long as antennal width; first flagellar segment as broad as long, longer than second which is longer than third which is nearly twice as broad as long; scape globose, about three-fourths as broad as long, covered with long white hair; maxilla with stipes practically as long as hind tibia, galea less than three times as long as broad; maxillary palpus a little shorter than eye, first segment about twice as long as broad, about three-fourths as long as second, both together shorter than next three together which are subequal; labial palpus a little longer than first four maxillary palpal segments; the first segment four times as long as broad, slightly longer than second which is slightly longer than either of last two. *Thorax*: Mesoscutum strongly, moderately closely punctured, the punctures between one and two puncture widths apart; mesoscutellum more densely punctate; interpunctural areas polished; mesoscutum with long, rather sparse hair not at all concealing integument; wings with yellowish tinge, the first transverse cubital vein offset from first recurrent by nearly its length; legs somewhat swollen; femora about half as broad as long, broadest medially; mid tibia about half, hind tibia about two-fifths as broad as long, broadest near apex; mid metatarsus about half, hind metatarsus nearly two-thirds as broad as long, succeeding segments of hind tarsus broader than long, strongly projecting dorso-apically. *Propodeum*: Enclosure strongly, closely carinate, about 15 carinae on either side of midline; posterior margin with three strong transverse carinae. *Abdomen*: Tergum with very fine sparse punctures, first segment mirror-like, practically impunctate; apical hair bands rather sparse, not concealing integument, that of apical segments no stronger than other hair; fourth sternite with a pair of recurved hooklets near posterior margin; fifth gently rounded medially; sixth with flat, testaceous, truncate apical projection about as long as broad, and covered with a short, dense tuft of testaceous hair; posterior arms of seventh broad to near their acute apices, the basal ventral flaps about two-thirds as long as remainder; apical process of eighth about three times as long as basal breadth, slightly expanded at apex.

*Female*.—Length 7 mm.; length of anterior wing 5 mm.; pubescence white to testaceous, rather sparse, not obscuring integument which has dark bluish and coppery reflections. *Head*: Face as long as broad; inner eye margins parallel; eye length six-sevenths interocular width at insertion of antennae; when viewed from in front, distance from posterior ocellus to vertex about equal to ocellar diameter; frons with broad shallow concavity laterad to posterior ocellus; distance from antennal socket to clypeus about two-thirds socket diameter; clypeus with about 30 coarse punctures and about as long as width between inner bases of teeth on apical margin which bears tawny hairs as long as clypeus; punctures of frons separated by about one puncture width except near ocelli; facial vestiture light testaceous, sparse; antennal flagellum partially dull brownish yellow on apical five segments. *Thorax*: Mesoscutum and scutellum shining, uniformly covered with fine punctures from one to two puncture widths apart, and with vestiture composed of numerous short hairs and a few scattered long ones, which together do not obscure integument, even from lateral view; hind wings with 7 hamuli; apical bristles of fore tibia testaceous; mid tibial spur reddish



testaceous throughout; tibial scopa whitish, moderately appressed; hind tibia and metatarsus each about four times as long as broad. *Propodeum*: Enclosure coarsely carinate, with about 20 carinae on either side of mid line and a few transverse carinae near posterior border, followed by a non-carinate slightly roughened area. *Abdomen*: Tergites with very fine, mostly setigerous punctures, first segment mirror-like, with about 75 minute punctures on dorsal disk; apical tergite borders transparent, not at all concealed by sparse hair fringes; anal fimbria reddish testaceous.

*Holotype* male, *allotype*, 6 *paratype* males and 4 *paratype* females: 16 miles east of Mt. Hamilton, Santa Clara Co., California, elevation 2000 ft., April 20, 1947, from *Gilia* (G. E. Bohart).

Some of the females differ from the allotype in being smaller and having wholly dark antennae.

This is very closely related to *D. sandhouseae* Michener but is easily distinguished in the male by the bare, impunctate area enclosed by the subantennal sutures and by the more swollen mid and hind tarsi. The female is somewhat larger than *sandhouseae* and has a slightly narrower face. Certain females of the two species are probably indistinguishable morphologically.

#### *Dufourea timberlakei* n. sp.

*Male*.—Length about 7 mm.; length of anterior wing 5 mm.; pubescence white, long, sparse; integument black without bluish or greenish reflections; last 10 flagellar segments yellow on outer sides. *Head*: Face ten-elevenths as long as broad; eyes slightly convergent below, their length six-sevenths as great as distance between them at antennal insertions; clypeus over twice as broad as long, densely punctured, covered with reclining white pubescence except for basal bare, impunctate strip; distance from antennal socket to clypeus about two-thirds socket diameter, half distance between sockets; cheek between antenna and base of mandible with patch of long brown hair; frons irregularly, sparsely punctate, the punctures averaging over one puncture width apart, nearly impunctate on broad, slightly concave area laterad to posterior ocellus; antennae short, scarcely over one-third length of anterior wing; scape at least half as broad as long; first flagellar segment broader than long, about three-fourths as long as second which is slightly longer than any of remaining segments; flagellum bare except for usual minute general pubescence; maxilla with stipes slightly shorter than hind tibia, galea less than half as long as stipes, rounded apically; maxillary palpus about two-thirds as long as stipes, first segment less than four times as long as broad, about three-fourths as long as second, as long as fourth and fifth together; labial palpus a little over half as long as stipes, first segment one and one-half times as long as second or third and fourth combined. *Thorax*: Mesoscutum rather sparsely punctate medially where many punctures are two or three puncture widths apart; punctures of mesoscutellum, sides of mesoscutum one to two puncture widths apart; dorsum, sides of thorax covered with long, sparse pubescence, mostly as long as scape, largely hiding short mesoscutal pubescence; wings slightly yellowish, the first transverse cubital vein offset from first recurrent by two thirds its own length; legs rather

stout but not highly modified; fore and mid femora half as wide as long; hind tibia evenly tapered, about three times as long as broad, with many hairs of inner margin two-thirds tibial length; metatarsi about four times as long as broad, parallel sided; second, third, fourth hind tarsal segments each about as long as broad. *Propodeum*: Enclosure strongly, evenly carinate, a straight transverse line drawn through middle cutting about 35 carinae. *Abdomen*: First tergite nearly impunctate on disk but subshining and reticulate, not mirror-like; remaining tergites with apical hair margins weakly defined laterally, not differentiated dorsally from semi-erect brownish tergal pubescence; sternum with first five segments rather densely covered with short, erect hair; fourth with a pair of tiny sublateral thorn-like projections; apical margin of fifth gently convex medially; sixth with a broad median circular depression and a short, broad, gently emarginate apical process, the depressed area bare, twice as broad as long, the process with rather long marginal hair ventrally; posterior arms of seventh about two-fifths as broad as long and evenly tapered, with apex rounded and margined by long hairs; posterior projection of eighth with apex twice as broad as narrowest, half as broad as broadest parts.

*Holotype* male and two *paratype* males Mt. Pinos, Ventura Co., California, May 31, 1942 (R. M. Bohart).

This is closest to *D. truncata* Timberlake but is larger, has a broader, less thickened process of the sixth sternite, a brown patch of hair above the sides of the clypeus, and no metallic blue color on the frons. One of the paratypes differs from the type in having a largely impunctate area in front of the median ocellus and scattered large punctures in the areas laterad to the lateral ocelli. Both paratypes have a more polished first abdominal tergite than has the type.

#### *Dufourea femorata* n. sp

*Male*.—Length about 11 mm., length of anterior wing 7 mm.; integument black with no tinge of blue, green, or copper; pubescence pale except for some black facial hair; body elongate. *Head*: Face a little broader than long; inner eye margins approximately parallel, slightly converging below, distance between them at antennal insertion slightly greater than eye length; face, as viewed directly from in front, with distance between posterior ocelli not greater than from one of them to posterior margin of vertex; distance from antennal socket to clypeus as great as socket diameter; area between posterior ocellus and upper margin of eye distinctly depressed; clypeus concealed by a long, white, dense, reclining tuft of hair extending beyond clypeus a distance equal to clypeal length, and with a few erect black hairs at its base; supra-clypeal area distinctly but sparsely punctate, with white, prostrate hair bounded laterally by long, erect, black hair extending upwards along inner eye margins; frons moderately coarsely, irregularly punctate, the punctures nearly contiguous except along eye margins and posterior to median ocellus where they are frequently separated by one or more puncture widths; antennae rather short, reaching about to tegulae, the flagellum black, not at all clubbed, slightly crenulate, the segments, as viewed from above, slightly longer than broad, the second but little longer than first or third, shorter than last; flagellar hairs pale brown to

whitish, as long as flagellar width, strongly bent near their middles toward flagellar apex, never more than three per segment, confined to first nine segments; scape over twice as long as broad; maxilla with stipes nearly one-third its length longer than eye, about as long as posterior tibia; galea a little less than three times as long as broad, narrowly rounded apically; maxillary palpus nearly four-fifths as long as stipes, first segment three times as long as broad, four-fifths as long as second, approximately equal to each of remaining segments; labial palpus three-fourths as long as maxillary, first segment five times as long as broad, a little longer than second maxillary palpal segment or second labial, one-third its length longer than third or fourth labial.

*Thorax:* Mesonotum uniformly, moderately closely, coarsely punctured, the punctures averaging a little less than one of their diameters apart except on median line, surface sparsely covered with long, white and a few brown hairs, some short, white pubescence; wings clear but distinctly stained with brownish yellow, the second transverse cubital vein separated from second recurrent by half its own length; legs strikingly modified; femur nearly as broad as long, produced ventrally at the middle to an angle of somewhat greater than 90 degrees; mid tibia one-third as broad as long, broadest apically, where it overhangs base of tarsus; mid tibial spur strongly curved; mid metatarsus greatly flattened, elongated, with a large, flat, semi-lunar, ventral production whose apex is directed distally, the segment being half as broad as long with its base having a small, inner, knot-like hump from which springs a dense tuft of stiff hairs; posterior femur with a strong, ventral, blunt, spine-like projection at its middle, directed at right angles to tibial axis, causing the segment to be as broad as long; posterior tibia arcuate, over one-third as broad as long, with a rather long brush of white hairs on outer apical half and a ridge of very long white hairs along inner ventral margin; posterior metatarsus nearly twice as long as remainder of tarsus, more than one-third as broad as long, polished on its outer surface; remaining tarsal segments, except the last, strongly produced posteriorly, over twice as broad as long.

*Propodeum:* Enclosure completely, strongly carinate, the carinae rather even and parallel, the inter-carinal spaces no broader than carinae.

*Abdomen:* Tergites finely, sparsely punctate, those on first tergite minute, many puncture widths apart and on next two more abundant, especially basally; white hair bands distinct but sparse; median hair of tergites brownish; third with apical lateral corner slightly projecting; fourth with a pair of strong, recurved hooklets just inside apical lateral corners, connected by low ridges with small ventrally directed teeth at the extreme corners; fifth emarginate apically, the emargination truncate medially; sixth with a convex, laterally impressed, median, longitudinal area, slightly broadened sub-apically, entirely covered with a short, fine, dense pad of hair, and terminating apically in a weakly bilobed, flat projection which extends slightly beyond sternite proper; dorsally placed under the apex of this area is a flat, rounded apical lobe, twice as long as broad, as long as mid line of sternite proper and covered with a dense, long tuft of white hair; posterior arms of seventh nearly three times as long as their basal, ventral flaps, carinate laterally, apically surrounded with dense yellow pubescence less than one-third as long as the arms; apical projec-

tion of eighth basally broadened, narrowest at middle, remaining parallel sided to apex which is less than one-fifth as broad as base.

*Female*.—Length about 11 mm., length of anterior wing 6.5 mm.; pubescence mostly pale; integument black as in male; body slightly elongate. *Head*: Face almost precisely as long as broad (a minute fraction broader); inner margins of eyes essentially parallel, the distance between them at antennal insertion somewhat greater than eye length; face, viewed directly from in front, with distance from posterior ocelli to posterior margin of vertex three-fourths that between them; distance from antennal socket to clypeus slightly less than socket diameter; clypeus coarsely, moderately densely punctate, the punctures, except on apical margin, little more than one of their diameters apart; hair of clypeus, inner eye margins, frons dark brown, that of antennal scapes, area between them with long white hairs mixed with a few dark ones; frons moderately strongly, densely punctate, the punctures between lower two-thirds of eyes and along entire inner eye margins mostly separated by one to two puncture widths, those of areas behind ocelli and between lateral ocellus and compound eye mostly less than one width apart; antennae black. *Thorax*: Elevated posterior portion of pronotum long laterally but nearly obsolete medially, the lateral margins with dense white hair tufts; mesonotum uniformly, rather finely, closely punctate, the punctures mostly separated by about one of their diameters; mesonotal surface provided with only a few long, dark brown hairs, and very few short ones except for microscopic pubescence scarcely protruding beyond punctures; apical bristles of fore and mid tibiae testaceous; mid tibial spur testaceous; about twelve times as long as broad, rather strongly curved at apex, with over fifteen small teeth having needle-fine apices, the apical sixth of spur edentate; tibial scopa rather dense, white, appressed, with a fringe of brownish hairs along upper margin. *Propodeum*: Enclosure coarsely, uniformly carinate, the carinae diverging posteriorly; a straight transverse line drawn through middle of enclosure cutting from twenty to twenty-five carinae. *Abdomen*: Tergites distinctly punctured, the first very sparsely, the punctures being several to many of their diameters apart; second tergite more closely punctured but with punctures two or more diameters apart; impunctate tergite borders testaceous; abdominal hair bands no longer than tergite borders, the first two incomplete; median hair of tergites dark brown; anal fimbria dark testaceous; apical tergite with distinct median, longitudinal carina.

*Holotype* male and *allotype*: Tuolumne Co., California, elev. 3500 ft., June 9, 1938, from *Gilia capitata*, (R. M. Bohart); *Paratypes*: 5 males, 36 females, same data; 7 males, 1 female, Marsh Creek Springs, Contra Costa Co., California, April 26, 1937, from *Gilia tricolor*, (G. E. Bohart, R. M. Bohart, C. D. Michener); 3 males, 4 females, same place and host, May 21, 1938, (G. E. Bohart, R. M. Bohart); 1 male, Butte Cr., near Chico, Butte Co., California, April 25, 1922, (Helen Van Duzee); 1 male, Antioch, Contra Costa Co., Calif., May 18, 1936, (M. A. Cazier); 1 male, Mt. Hamilton, Santa Clara Co., California, April 26, 1913, (J. C. Bridwell).

Variation is slight in this species. The first transverse cubital and first recurrent veins are sometimes nearly contiguous. The size of the

relatively impunctate areas of the frons is also somewhat variable. Body size is often smaller than that described for the holotype.

This is easily distinguished from all except *D. virgata* (Ckll.) by its large size, dense punctures, flattened face, and pale pubescence in both sexes, and in the male by its peculiar leg characters. It can be told from *D. virgata* by its larger size, finer propodeal sculpturing, and the reversed condition in degree of production of mid and hind femora.

REVIEW OF THE WEEVILS OF THE TRIBE OPHARYASTINI OF AMERICA NORTH OF MEXICO, by A. C. DAVIS. Proceedings of the United States National Museum, Vol. 96, No. 3207, pages 483-551, 1947.

While all taxonomists must sometimes publish descriptions of new species, reviews and revisions have seemed to the reviewer a far more valuable contribution to the literature of entomology. It is regrettable that the death of the author brought his work on the weevils to an untimely end, for he had evidently made much sound progress toward the comprehensive revision of difficult groups. Fortunately this portion of his work was sufficiently advanced to be prepared for publication by L. L. Buchanan, himself an expert in the taxonomy of the weevils.

The article includes keys to genera, groups and species, and in some cases the species are keyed by genitalic structure as well as by superficial characters. The treatment of species includes ample descriptions, notes on geographic distribution and comparative notes, with brief references to the bibliography. The genitalia of many species are illustrated by text figures. Two Mexican species are included, but according to Mr. Buchanan's footnote the study of Mexican species in general was not sufficiently advanced to permit the treatment of all of them in this publication.—A. W. L.

PULGAS, BIBLIOGRAFIA, CATALOGO E HOSPEDADORES, by A. DA COSTA LIMA and C. R. HATHAWAY. Monografias do Instituto Oswaldo Cruz, No. 4, 522 pages, December, 1946. Rio de Janeiro, Brazil.

The difficulties experienced by the authors in their work on neotropical fleas led them to undertake the preparation of this catalogue, which covers the fauna of the entire world. It is an ample and well organized work which should be of great value to specialists in the order.

The first section of the catalog is a bibliography occupying sixty-six pages. It may prove inconvenient since the arrangement is chronological instead of alphabetic, but the listing of such a wealth of published material cannot fail to be helpful. The bibliography is followed by a taxonomic index. The catalog proper fills two hundred forty-four pages. Under the ordinal name Suctoria an extensive synonymy and bibliography are followed by the usual catalog treatment of the subordinate divisions and species. Genotypes are cited and the synonymy of both groups and species is apparently fully covered. Numerous references to the literature are given in addition to those in which names were originally proposed. Additional material consists of the distribution of species and a list of the host species. The catalog is followed by a taxonomic list of host species, each entry including a list of the parasites recorded from that host. An excellent general index covers all of these parts, listing alphabetically the names of authors, host species and all taxonomic categories.

The reviewer is constantly impressed with the labor involved in the preparation of adequate catalogs. As compared with revisional studies they seem unrewarding to their authors. We can only hope that the authors are fully aware of the service that they render to other entomologists and of the appreciation that others must feel for their help.—A. W. L.

# THE IDENTITY OF THE PHLEBOTOMUS ASSOCIATED WITH BARTONELLOSIS IN COLOMBIA

LLOYD E. ROZEBOOM<sup>1</sup>

During 1935 an outbreak of Oroya fever occurred in southeastern Colombia. The history of the epidemic was reviewed by Brumpt and Brumpt (1942) and Jaramillo (1943), who investigated its epidemiology in Colombia; these authors concluded that the disease was introduced into this region, perhaps by returning soldiers or by the "colporteurs" who travel from village to village. With the aid of Dr. Osorno a number of *Phlebotomus* were taken in the epidemic zone; these insects were studied by Ristorcelli and Van Ty (1941 a and b), who identified them as *P. longipalpis*, *P. evansi*, *P. osoroi* n. sp., *P. colombianus* n. sp., and *P. monticolus* var. *incarium* n. var.

In 1943 I received from Colombia a small series of *Phlebotomus* females which I provisionally identified as *P. verrucarum*; however, the accuracy of this identification became especially doubtful with the receipt of the 1945 Annual Report of the Gorgas Memorial Laboratory, in which Hertig noted that he was unable to find any Peruvian *Phlebotomus* in Colombia. When the descriptions by Ristorcelli and Van Ty were obtained it became evident that the specimens I had received had been described by these authors as *colombianus* and *incarium*.

Recently a large series of *Phlebotomus* from the bartonellosis region of Colombia was received from Dr. Juan A. Montoya. Most of these specimens were found to be *incarium* and *colombianus*; however, it soon became evident that it was not possible to separate the females according to the characters described by Ristorcelli and Van Ty, and furthermore, it appeared that no differentiating characters could be found between the females from Colombia and *verrucarum* of Peru as described by Shannon (1929) and Hertig (1938). As males were present in the collections received from Dr. Montoya, the purpose of this study was to compare the Colombian insects with *verrucarum* from Peru in order to establish the relationship between *colombianus*, *incarium*, and *verrucarum*.

## COMPARISON OF THE FEMALES

An analysis of the descriptions by Ristorcelli and Van Ty will show that the principal difference between *colombianus* and *incarium* is in the structure of the spermathecae, which are smooth-walled, pyriform organs in *colombianus*, while in *incarium* they show varying degrees of collapse. The females from Colombia were grouped according to the spermathecal characters described by Ristorcelli and Van Ty. Those with the collapsed spermathecae of *incarium* were designated as type I (figs. 1-3); those with the expanded spermathecae of *colombianus* as type II (fig. 6); and in addition a type III was recognized in which the

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spermathecae were partially contracted but instead of narrowing down to the head, as illustrated for *incarum*, they were broad apically, so that they were somewhat beet-shaped (fig. 4). The principal reason for recognizing this type was that these specimens could be assigned with certainty neither to *colombianus* nor *incarum*. Of the 71 specimens studied, 40 were type I, 10 were type II, and 21 were type III. After grouping the specimens according to the spermathecae, other characters were studied in an attempt to find differences between the groups which might supplement those of the spermathecae; in addition, information concerning *verrucarum* was obtained from Shannon (1929) and Hertig (1938), by examination of Townsend's type and two cotype slides in the U. S. National Museum, and by staining and dissecting three female *verrucarum* that had been collected in Peru and identified by Hertig. Measurements and certain ratios are summarized in Table I; the former are given in microns and represent the mean measurements of Townsend's type and cotypes of *verrucarum*, the three Peruvian specimens of *verrucarum* and the three types of Colombian specimens. Measurements of *colombianus* and *incarum* are taken directly from Ristorcelli and Van Ty (1941). Because of the wide variations in the wing vein ratios the range rather than the mean of these values is listed. The shrinkage of the spermathecae and their ducts limited the significance of the mean values, and the range of the measurements of these structures is given.

The total length of the specimens is not given in the table, as the great variation observed in the size of the abdomen would seem to make its length of little significance for purposes of comparison. In general, the overall length of the Colombian specimens averaged about 2.5 mm., which is similar to that of the other forms under consideration.

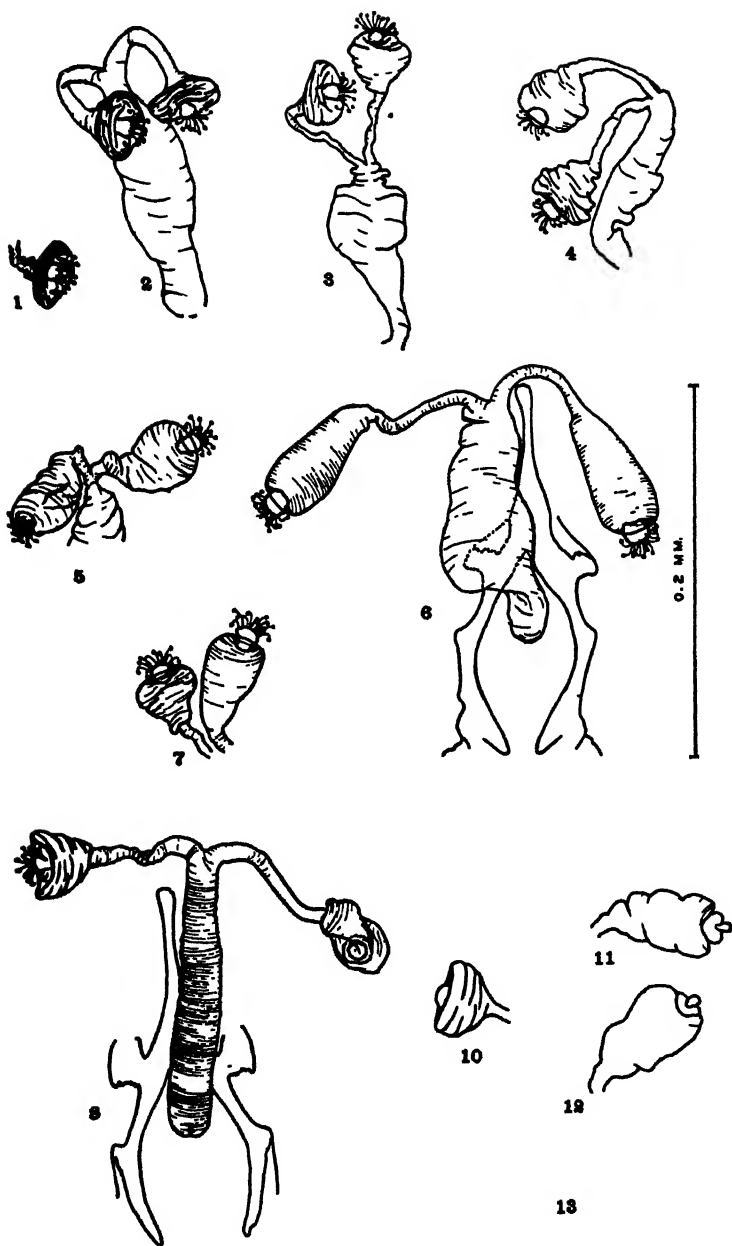
The antennal formula in *colombianus* and *incarum*, according to Ristorcelli and Van Ty, is  $III > IV + V$ ;  $III < IV + V + VI$ ; this is also the formula of the types of *verrucarum* and of the Colombian specimens.

There is considerable variation in the length of the palpal segments. In Townsend's types, the fifth segment is relatively much shorter than in the other Peruvian *verrucarum*. Segment II may be shorter, equal to, or longer than III, so that the formula for *verrucarum* and for the Colombian specimens is 1, 4, 2, 3, 5; 1, 4, (2, 3), 5; or 1, 4, 3, 2, 5. The measurements of the palp of a single specimen of *incarum* given by Ristorcelli and Van Ty are remarkably short, totalling less than the usual length of the "short-palp" species, in which segment V is shorter than segment III. None of the "type I" specimens, with spermathecae like those described for *incarum*, has such a short palp.

The modified spines of Newstead are described as being present on the apical three-fifths of palpal segment III in *colombianus*; they were

#### EXPLANATION OF PLATE I

FIGS. 1-3. *P. colombianus* ("Type I"—*incarum*). Spermathecae and ducts. FIG. 4. *P. colombianus* ("Type III"). Spermathecae and ducts. FIG. 5. *P. colombianus*. Spermathecae and ducts. FIG. 6. *P. colombianus* ("Type II"). Spermathecae and ducts. FIG. 7. *P. colombianus*. Spermathecae and ducts. FIG. 8. *P. verrucarum*. Spermathecae and ducts. FIGS. 9 and 10. *P. verrucarum*. Spermathecae of Townsend's cotypes. FIGS. 11-13. *P. verrucarum*. Spermathecae.





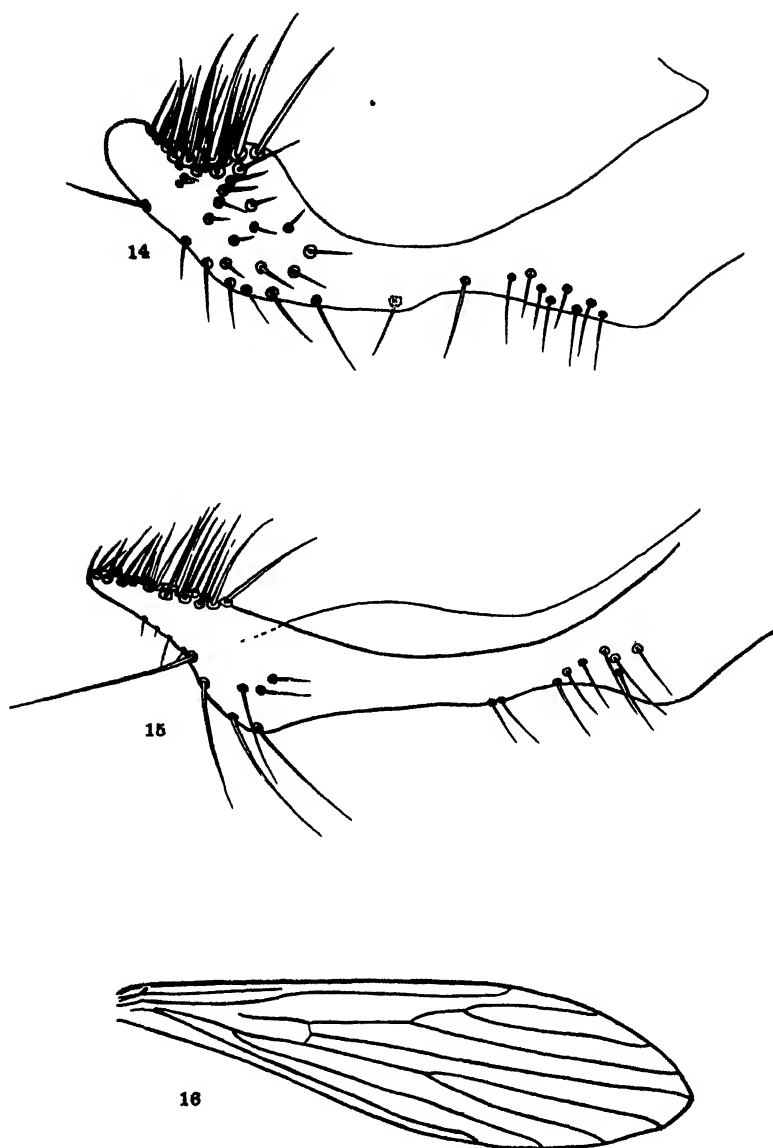


FIG. 14. *P. colombianus*. Median clasper of male genitalia. FIG. 15. *P. verrucarum*. Median clasper of male genitalia. FIG. 16. *P. colombianus*. Wing of male.

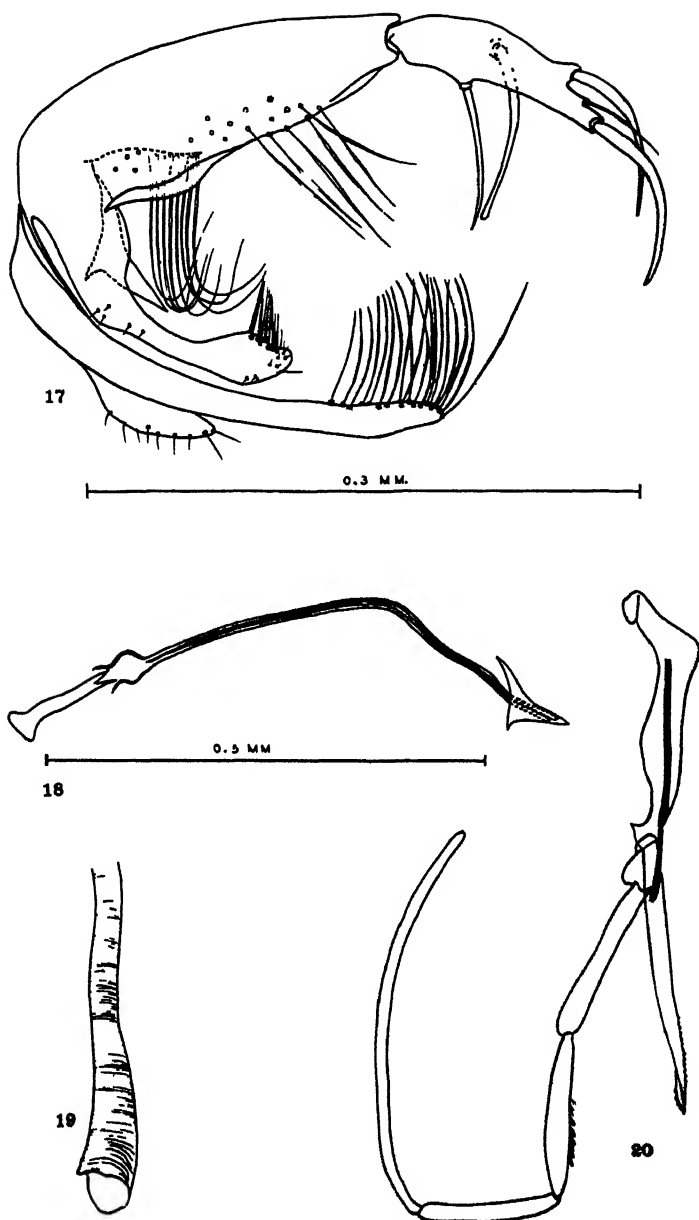


FIG. 17. *P. colombianus*. Male genitalia. FIG. 18. *P. colombianus*. Genital filaments and pump. FIG. 19. *P. colombianus*. Tip of genital filament. FIG. 20. *P. colombianus*. Palp, maxilla, and maxillary sclerotization of female.

approximately in the same position in *verrucarum* and in the Colombian specimens, although they did not extend to the apex of the segment and in some individuals occupied a more central position.

No distinct difference in the bucco-pharynx could be found between *verrucarum* and the other forms. All possess four horizontal teeth; the

TABLE I  
COMPARISON OF FEMALES FROM PERU AND COLOMBIA  
Measurements in microns and ratios

	<i>verrucarum</i>			colom- bianus	incarum	Specimens from Colombia		
	Holotype and Cotypes	From Shannon and Hertig	Speci- mens from Peru			"in- carum" Type I	"colom- bianus" Type II	Type III
Head and clypeus.	447	.....	453	421	432	418	425	420
Scutum and scutellum.....	776	.....	585	648	668	528	556	536
Eye								
Eye-vertex.....	1.6	1.1	1.6	.....	.....	1.9	1.8	1.9
Antenna.....	1548	2000	1633	.....	.....	1605	1680	1638
Palp I.....	40	30	48	46-50	12	45	43	47
II.....	187	220	191	151-172	51	171	171	169
III.....	170	190	191	180-194	58	172	189	171
IV.....	110	130	135	118-136	35	129	134	128
V.....	248	360	389	396-432	154	423	430	441
Epipharynx.....	.....	.....	363	298-320	340	313	321	308
A III/E.....	.....	.....	0.8-0.9	0.9	0.9	0.9-1.3	0.9-1.5	0.9-1.1
Wing—								
Length.....	2423	2800	2531	2192	2036	2143	2112	2112
Width.....	745	800	752	702	750	665	677	657
Alpha.....	726	900	711	648	669	608	616	602
Beta.....	231	300	242	172	216	185	189	192
Gamma.....	483	520	459	378	432	382	382	374
Delta.....	308	340	284	248	280	223	235	208
Alpha/Beta.....	2.8-3.4	3.0	2.6-3.3	3.7-4.5	3.1	2.6-4.0	2.9-3.7	2.6-3.8
Alpha/Gamma..	1.3-1.6	1.7	1.3-1.7	1.7	1.5	1.2-1.9	1.4-1.8	1.5-1.8
Alpha/Delta....	2.3-2.4	2.7	2.4-2.9	2.6	2.4	2.5-3.6	2.3-3.1	2.3-3.3
Tibia								
Femur—								
Foreleg.....	1.1	.....	1.1	1.1	1.1	1.1	1.1	1.1
Midleg.....	1.3	.....	1.3	1.3	1.3	1.4	1.3	1.4
Hindleg.....	1.5	1.7	1.5	1.5	1.5	1.5	1.5	1.5
Spermatheca—								
Length.....	.....	.....	32	.....	.....	16-32	55-95	32-48
Width.....	.....	.....	24	.....	.....	32	32	32
Common duct....	.....	.....	112-145	.....	.....	80-104	120-136	95-128
Individual duct..	.....	.....	70	.....	.....	40	40-65	40-65

vertical denticles are usually arranged in an irregular double row, at least in the middle, although in some specimens the arrangement is such that it could be considered to be an irregular single row; the pigmented area usually is distinct although in some specimens it is indistinct; the upper portion of the pharynx is striated with short, denticulated lines. Hertig (1938) describes the sclerotized arch of

*verrucarum* as being complete and distinct; this also is true of the three *verrucarum* females from Peru. In the Colombian specimens the middle portion of the arch is less heavily pigmented, so that it is less distinct in this region, although the outline of the complete arch usually can be made out.

The posterior, ribbon-like band of the maxillary sclerotization (fig. 20) is broad in the Colombian specimens and is similar to Hertig's

TABLE II  
COMPARISON OF MALES FROM PERU AND COLOMBIA  
Measurements in microns and ratios

	<i>Verrucarum</i>		Specimens from Colombia
	From Shannon	Specimens from Peru	
Head and clypeus.....		396	356
Thorax.....		498	430
Eye/Eye-vertex.....		1.8	1.9
Antenna.....	2340-2370	1841	1650
Palp I.....	25-30	41	37
II.....	210-190	155	134
III.....	180-180	156	145
IV.....	130-150	116	114
V.....	270-480	332	357
Epipharynx.....		252	205
A III/E.....		1.2-1.4	1.3-1.7
Wing—Length.....	2350-2700	2002	1703
Width.....	650-650	546	477
Alpha.....	630-600	511	402
Beta.....	200-280	209	157
Gamma.....	450-470	380	303
Delta.....	180-200	162	98
Alpha/Beta.....	3.1-2.1	1.9-2.7	2.2-2.8
Alpha/Gamma.....	1.4-1.3	1.2-1.4	1.1-1.5
Alpha/Delta.....	3.5-3.0	2.9-3.5	3.4-5.3
<b>Tibia</b>			
Femur—Foreleg.....		1.1	1.1
Midleg.....		1.4	1.4
Hindleg.....	1.5-1.6	1.6	1.5
Genitalia—Coxite.....		237	206
Style.....		137	117
Median Clasper.....		200	168
Lower Clasper.....		327	254
Pump.....		162	172
Filaments.....		504	479

description of this structure in *verrucarum*. There is a band of sclerotization extending along the rod for some distance; this was also seen in the Peruvian *verrucarum*.

There is no real difference in the wing vein ratios. The relative lengths of the tibiae and femora are the same.

An examination of a series of spermathecae will show that the differences in their appearance are due entirely to the degree of collapse.

Shannon described the spermatheca of *verrucarum* as being "rosebud-shaped when contracted, bladder-shaped when expanded." Spermathecae of Shannon's specimens are illustrated in figures 11-13; the expanded spermatheca is similar to that of *colombianus*; the collapsed spermatheca is not unlike that of *incarum*. The holotype and two cotypes of *verrucarum* are not cleared, and mounted in balsam. The outlines of the spermathecae of the cotypes can be made out with some difficulty; they are illustrated in figures 9 and 10, and it will be noted that they also show a moderate degree of collapse. The spermathecae and ducts of the Peruvian *verrucarum* are illustrated in figure 8; the former are collapsed, in one case longitudinally, the individual duct is short, and the median duct appears to differ from that of the Colombian forms in being of almost uniform diameter throughout its length. It is not certain that this character could be a point of difference between *verrucarum* and the Colombian forms, as a rather narrow common duct was observed in an occasional specimen from Colombia. This condition may be due to techniques of staining and mounting, as for example, incomplete clearing with KOH before staining with acid fuchsin. The spermathecae and ducts of the Colombian specimens are illustrated in figures 1 to 7. In all, the individual duct and common duct are short, and similar to these structures in *verrucarum*, although the common duct usually is swollen. There is no sharp distinction between the collapsed, partially expanded, and fully expanded spermathecae. Figure 5 illustrates spermathecae which are slightly shrunken; figure 7 illustrates one partially collapsed and one fully expanded spermatheca from a single specimen. Furthermore, in the process of dissecting the spermathecae from the abdomen and mounting them in balsam, they have been observed to change from pyriform bodies into completely collapsed disks.

In summary, from the characters described above and those given in Table I, there seems to be no clear-cut way to separate the female of *verrucarum* from the Colombian specimens studied by the author and those described by Ristorelli and Van Ty as *colombianus* and *incarum*.

#### COMPARISON OF THE MALES

Associated with the females in the collections from Colombia so far studied, were 42 males. These males were compared with 3 male *verrucarum* collected in Peru by Hertig, and with Shannon's description. Shannon's mounted specimens in the U. S. National Museum were also examined. Table II summarizes the mean measurements in microns of the three Peruvian *verrucarum* and of 23 Colombian specimens; Shannon's measurements of *verrucarum* are given in microns; and certain ratios are listed, which in the case of the wing veins and A III/E represent the range instead of the mean. The total length of the Colombian males averaged about 2.2 mm., and that of the three Peruvian males was about the same. Shannon's specimens ranged from 2.2 to 2.8 mm. There is nothing in Table II which would permit the separation of the males from the two regions. The antennal formula is the same for each group: III > IV + V; III < IV + V + VI. Shannon gives the palpal formula for *verrucarum* as being 1, 4, 3, 2, 5; in the three specimens from Peru it was 1, 4, 2, 3, 5, or 1, 4, (2, 3), 5

In the Colombian specimens it was 1, 4, 2, 3, 5; 1, 4, (2, 3), 5, or 1, 4, 3, 2, 5.

In the male genitalia was found the only consistent difference between *verrucarum* from Peru and the Colombian males. In the former the median clasper (fig. 15) is swollen on the lower margin beyond the middle and tapers rather gradually to the apex, and there is a patch of upright setae on the upper surface at the extreme tip. In the male from Colombia (fig. 14) the median clasper also is swollen beyond the middle, but the upper margin is more concave, giving the shaft a more curved appearance; the apical portion is more swollen and does not taper gradually; the apex is broadly rounded, and the patch of setae on the upper surface is subapical in position. Furthermore, in *verrucarum* there is a dense clump of long setae on the ventral surface of the coxite below the apex; in *colombianus* these setae may be absent or are represented by only a few hairs.

#### THE MALE OF *P. COLOMBIANUS*

Because of the small but consistent differences in the males, *colombianus* would appear to be a different taxonomic entity than *verrucarum*, and as the male of the former has not been known, further descriptive notes are presented.

Total length about 2.2 mm. Wing illustrated in figure 16.

Geniculate spines of antenna without basal spur; situated one-third the distance from the apex on segment III, short, not reaching the apex of the segment; on the other segments they are situated near the base and are very short, not reaching the middle of the segments.

*Genitalia* (figs. 14, 17, 18, and 19).—Basal segment of upper clasper (coxite) with a basal lobe; a basal tuft near the lobe consisting of several long hairs arranged in a row; an irregular row of long, scale-like setae on inner margin before the apex. Distal segment of upper clasper (style) with four spines and a hair; arranged as follows: an apical and a subapical spine, between which is inserted the hair, and two spines inserted just before the middle. Lower clasper longer than the coxite; a group of long, scale-like setae at apex. Median clasper with upper surface strongly concave; the lower margin angled before the middle; the middle portion narrowed; the distal portion swollen and narrowing abruptly into a broadly rounded tip; a subapical patch of short, stout, upwardly-pointing setae before the tip on the upper surface; a number of small scattered setae on the inner surface of the swollen apical portion; and a short but prominent subapical seta on the lower margin; short setae along the lower margin of the shaft, somewhat denser beyond the angle. Genital spicules about three times the length of the pump, striated and somewhat enlarged apically, the tips blunt.

#### DISCUSSION

In spite of the exceedingly short palp described for *incarnum*, a number of females from Colombia were identified as this form because they agreed in all other respects with the description given by Risticelli and Van Ty, particularly in the structure of the spermathecae. Because all degrees of variation were seen between the completely collapsed and fully expanded spermathecae, and as no other differences could be

found, it is concluded that *P. monticolus* var. *incarnum* is a synonym of *P. colombianus*. Additional evidence that the three types of Colombian females studied are all one species results from the fact that all of the 42 males associated with these females represent a single species.

*P. colombianus* is very closely related to *verrucarum*. There seem to be no definite characters by which the females can be separated from one another. The only certain means of distinction between the males appears to be in the shape of the apical portion of the median clasper. In *verrucarum* the basal and subapical hair tufts on the coxite are more dense, and the lower clasper is longer.

Whether *colombianus* is sufficiently distinct from *verrucarum* to merit specific rank, or should be considered to be a geographically separated subspecies, can not be determined by morphological comparisons. *P. colombianus* must be very similar to *verrucarum* in its habits, especially in its willingness to utilize man as a source of blood. In the collections so far identified from the bartonellosis area of Colombia it was the predominant species. As many of the specimens were captured in houses in an engorged state, this species is to be suspected as being responsible for the transmission of Oroya fever in Colombia.

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